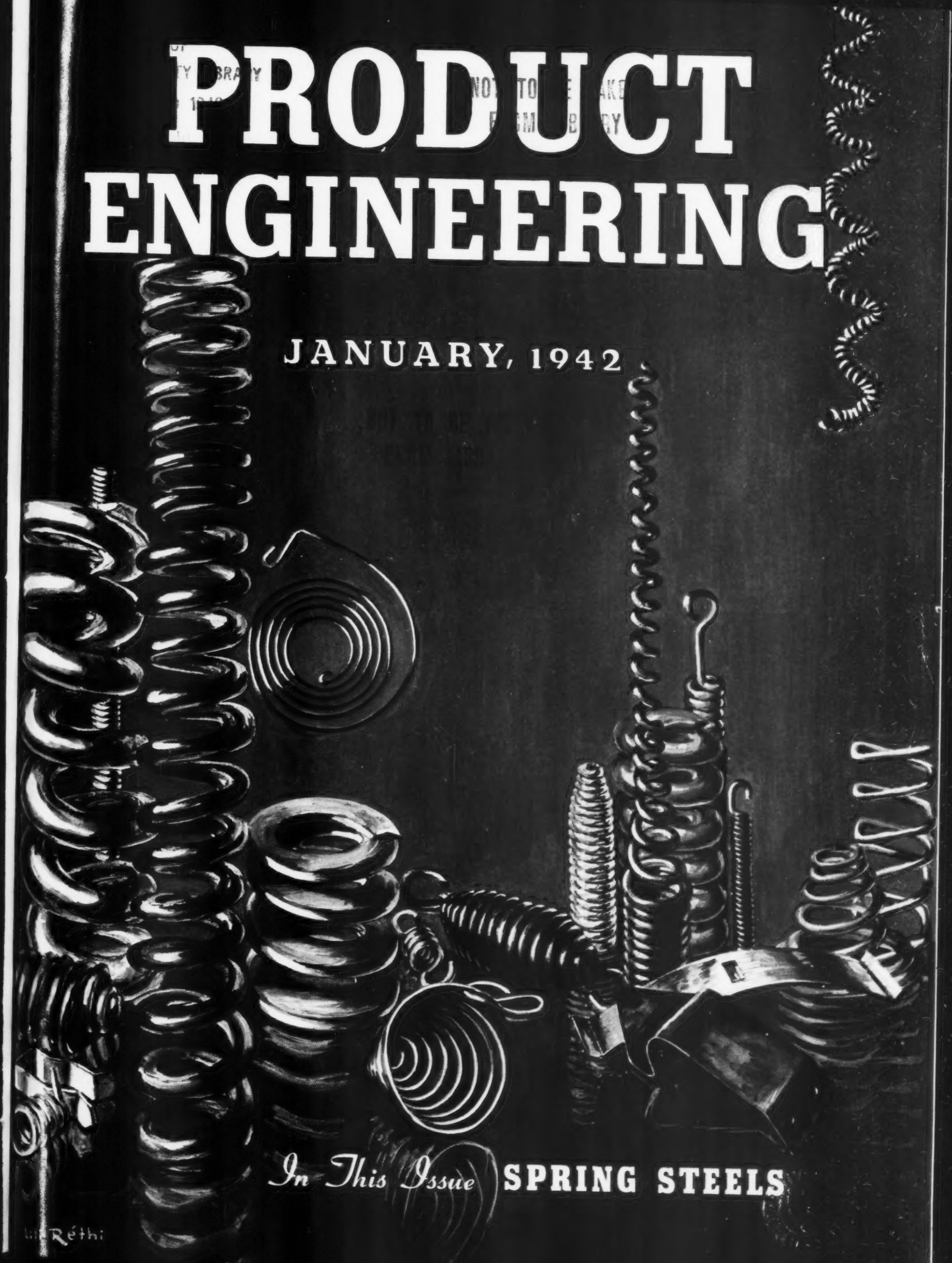
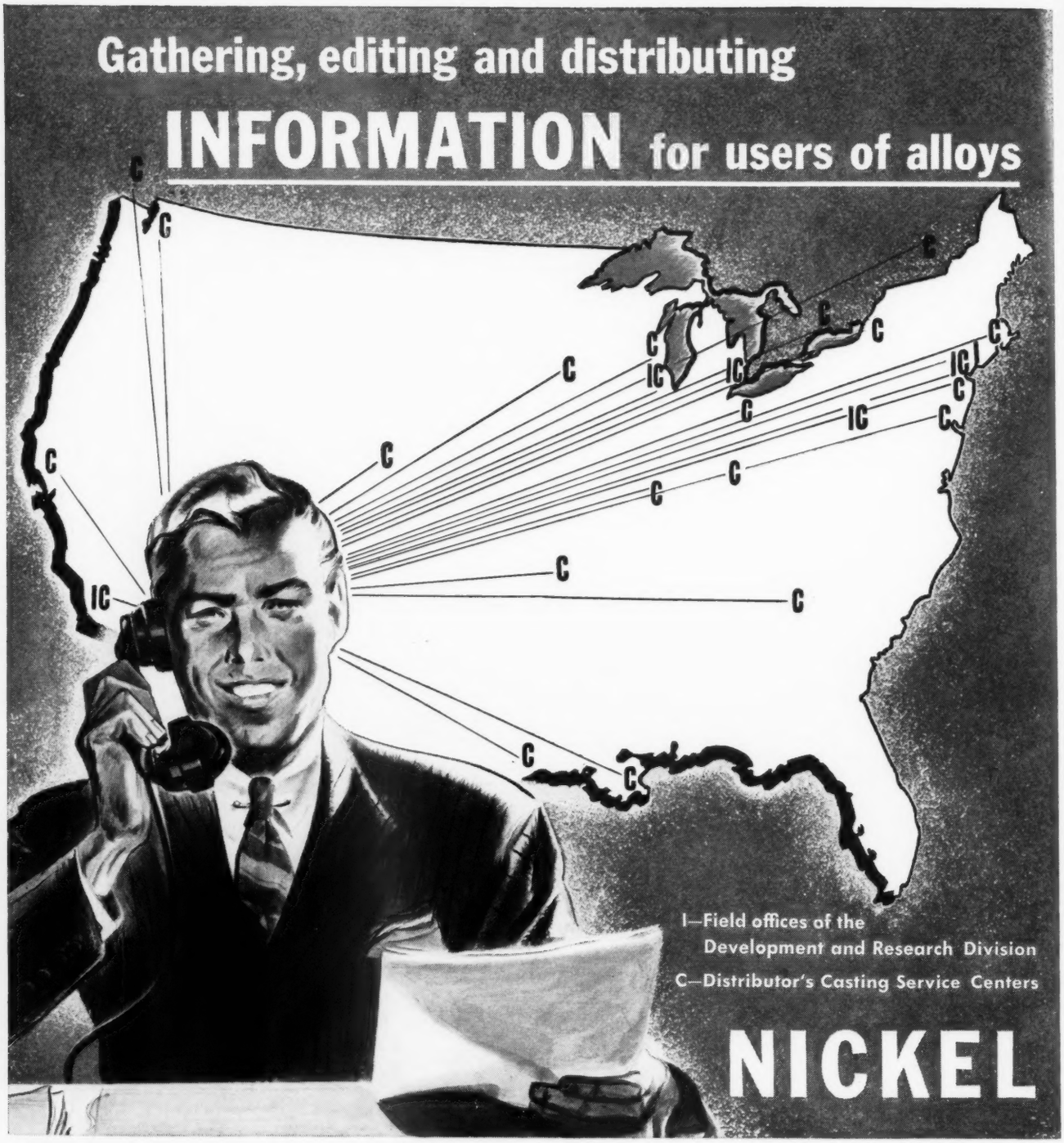
PRODUCT ENGINEERING

JANUARY, 1942



In This Issue **SPRING STEELS**

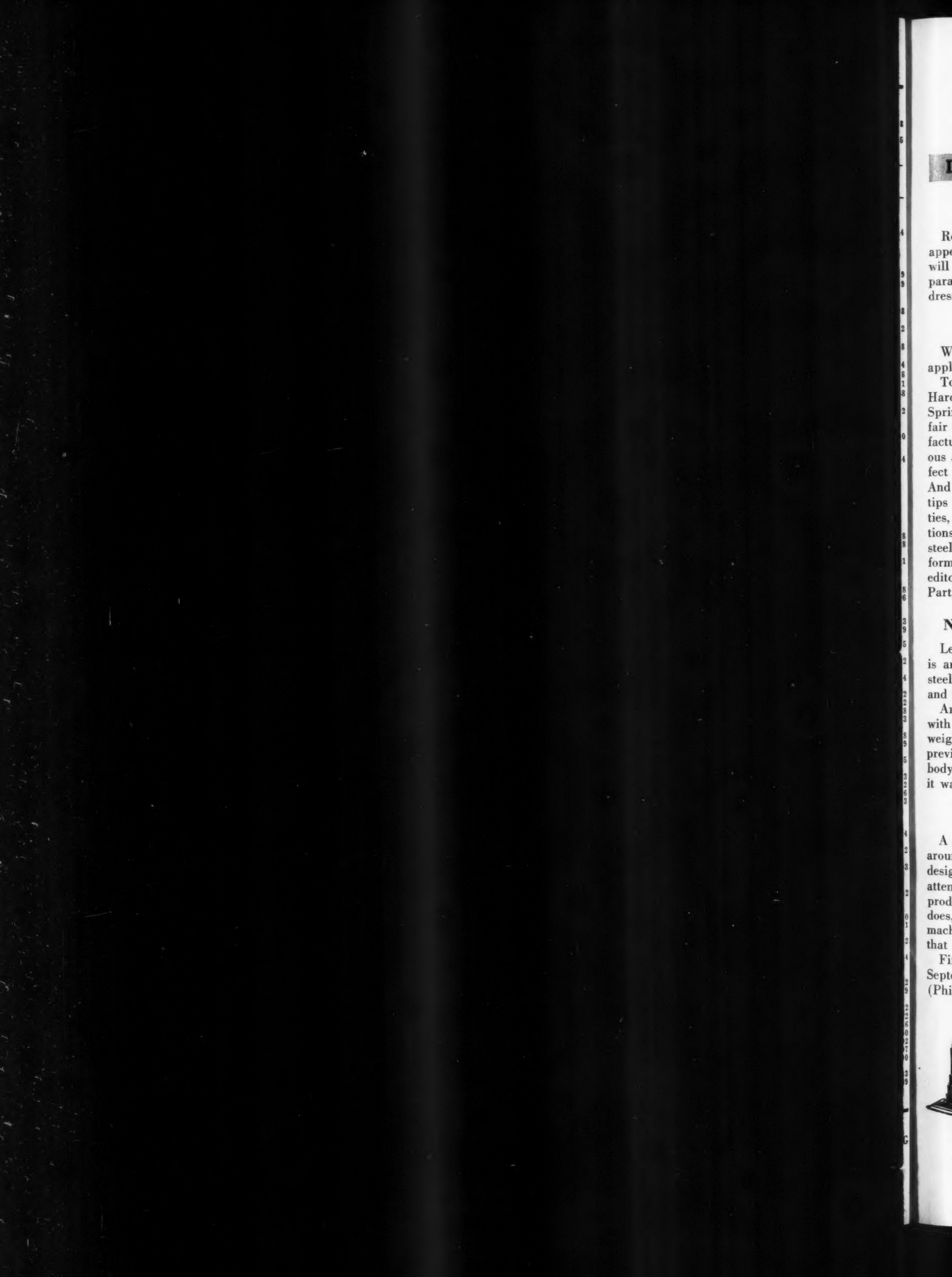

Gathering, editing and distributing
INFORMATION for users of alloys
I—Field offices of the Development and Research Division
C—Distributor's Casting Service Centers
NICKEL

To aid users of Nickel alloys, thirty service centers are maintained in industrial areas. From these strategically located key points, our field representatives are on call to advise American industry about the selection, fabrication and uses of ferrous and non-ferrous materials. Assistance is also given on problems arising from the temporary lack of Nickel.

Through the years, research, field studies and user experience have all contributed to a fund of practical, time-proved information. Many of these data have been compiled in convenient printed form, useful both to experienced men handling new materials or performing unfamiliar operations . . . and to the many new employees.

Now . . . when minutes and materials are so vital . . . make full use of this metal-working experience. Send for a check list of helpful printed pieces on the selection, treatment, fabrication and use of Nickel alloys, or send your specific questions to:

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.



PRODUCT ENGINEERING

VOLUME XIII JANUARY, 1942 NUMBER 1

Spring Steels—I 2
H. CARLSON

Modern Designs 6

Difference Calculus 13
A. H. CHURCH

Patent Procedure 16
MILES HENNINGER

Color for Efficiency 19
ARTHUR A. BRAINERD AND MATT DENNING

Photo-Tracings 23
LESTER C. JONES

Electrical Timing Devices 26

Glass in Parts Design 28

Dynamic Balancing 32
F. L. SCHWARTZ

Optional Materials 35
- STAINLESS CLAD STEEL 35
- MALLEABLE CAST IRON 37
- LAMINATED PLASTICS 39
- LEAD COATINGS 41
- CARTRIDGE BRASS 42

Helical Tension Spring Tables—III 59
PAUL KLAMP

Editorial 1
Causes and Cures 31
Question and Comment 47
News and Summaries 50
Engineering in Washington 53
New Materials and Parts 54
Books and Bulletins 58

IN THIS ISSUE

What Can I Do?

Reprints of this effectively worded appeal to all workers and industries will be sent free (with the last three paragraphs omitted) upon request addressed to the editor.

Spring Steels

What spring steel is best for a given application?

To answer this question, says author Harold Carlson (chief engineer, Lee Spring Company), you've got to have a fair knowledge of steel and wire manufacture. You should know how the various alloying elements for steel wire affect cost and operating characteristics. And you should have at your fingertips data comparing strength, properties, tolerances, and general applications of the various types of spring steels. Mr. Carlson gives all this information, beginning on page 2 of the editorial section. Next month, with Part II, he will finish the job.

No More Aluminum Buses

Leading Modern Design of the month is an a.c.f. bus with a body made of steel—all steel except for a few plastic and high-strength plywood parts.

Amazing feat: The new steel coach, with no sacrifices in comfort or quality, weighs almost 2,000 lb. less than the previous model, which had an aluminum body. On pages 6 to 9 is shown how it was done.

Color for Efficiency

A new era of machine finishes is just around the corner, we believe. Machine designers will soon pay just as much attention to the color scheme of their products as the automobile designer does, but not for the same reason. The machine designer's aim will be color that will assist operators to see better.

First evidence of the trend came last September, when Arthur A. Brainerd (Philadelphia Electric Company) and

G. F. NORDENHOLT, *Editor*
JOSEPH KERR, *Managing Editor*
N. O. WYNKOOP, *Publisher*
W. E. KENNEDY, *Manager*

Assistant Editors
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PAUL WOOTON, *Washington*

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Matt Denning (DuPont) read before I.E.S. a paper stating that a light buff-medium gray combination is best for machine tools. Their results are based upon research. Turn to page 19 for the complete story and the first accurate color pictures published on the subject.

DuPont engineers, we are told, will continue with research on the psychological factors of color for all types of machinery and factory interiors.

Dynamic Balancing

As speeds of modern machines increase, so do the problems of eliminating vibrations that are caused by unbalance of rotating elements. In fact, the forces that produce these vibrations increase as the square of the speed.

Conditions necessary for static and dynamic balance are described by F. L. Schwartz in his article beginning on page 32. The author explains how these principles are applied in balancing machines, describes electrical pick-up systems for measuring degree and location of unbalancing forces.

Electrical Timing Devices

There are many, many mechanisms for automatically timing an electrical machine or process. Assistant editor Van Voorhis, studying scores of sources, has found 13 fundamental devices and presents sketches of them in this month's mechanism spread, page 26. Most common one sketched is a clock-operated cam, and most unique one is based upon time it takes an electrically heated wire to droop.

Photo-Tracings

Time-saver hint to drafting departments: Take photographs of assemblies directly on tracing cloth. After adding instructions and notes on the tracing, make blueprints for release to the shop.

Result: A photographic picture which is easier for shop workers to understand than the average assembly drawing, and much time saved in drafting. See page 23 for full details of the method as applied by Lockheed Aircraft Corporation. L. C. Jones is the narrator.

Materials Data

This month's special section on materials covers malleable iron, stainless clad steel, laminated phenolic plastics, lead coatings and cartridge brass. Pages 37-38 give hints on fabrication and design of malleable iron castings, as well as a discussion of ductility, shock resistance, strength, ease of machining, and corrosion resistance. Stainless clad steel sometimes can be fabricated with unexpected ease; two pages of data show its advantages, its properties, and what it is used for.

Laminated phenolics data, including grades classified by type of filler, properties, and applications, are packed into pages 39 and 40. Lead coatings (page 41) may be what you are looking for as a substitute for zinc galvanizing, tin plating or tin-lead solders. The new 5-page installment of the Wilkins-Bunn series on brasses shows the effect of "ready to finish" grain size on the physical properties of cartridge brass.

Difference Calculus

If you're faced with a problem of integration where mathematical solutions are impossible or too cumbersome, turn to page 13 for an approximate method that can be used with a surprising degree of accuracy, as explained by A. H. Church, assistant professor of machine design at New York University.

Glass in Parts Design

Glass is a material not to be overlooked when searching for alternates. Improved physical properties and new techniques of fabrication have made glass suitable for many new mechanical uses. Even dimensional tolerances, usually the bugaboo of glass parts, are being brought down to a respectably fine point by a new "electric welding" process. Following up the brief article published in the November, 1941, issue, the complete article beginning on page 28 of this issue talks about the pros and cons of glass in parts design and gives more design data.

Patent Procedure

The admittedly imperfect U. S. patent system still offers individuals and small companies an opportunity to lift themselves above the average. However, knowledge of the practical working of the system is necessary to make use of the opportunity. A series of articles beginning on page 16 of this issue is the result of a class conducted by Miles Henninger, the author.

Tension Springs

Reference Book Sheets this month conclude the Paul Klamp series of articles on tension springs. Similar to the earlier series on compression springs by Mr. Klamp, these articles have given the data necessary for a simple but accurate method of selecting springs.

WHAT'S COMING

Salvage

Today's No. 1 problem is materials. There are five good ways to economize on them: substitution; design simplification; design for minimum scrap in manufacture; reclamation of scrap; and finally, salvage of rejected parts.

This last will be the subject of a comprehensive article in PRODUCT ENGINEERING for February, wherein will be set forth salvage specifications and how they are established. Look for information on various methods for salvaging castings, forgings and parts machined undersize, and of greatest importance, design modifications that will avoid manufacturing conditions that induce production of defective parts.

Vibration Control

Vibrations on the loose must be stopped before they are transmitted to machine frames, foundations or buildings where they may create noise, high fatigue stresses, or interfere with other equipment. Leon Wallerstein, Jr., vibration engineer of Lord Manufacturing Company, will show in next month's lead article, how rubber mountings can be applied to keep vibration within bounds.

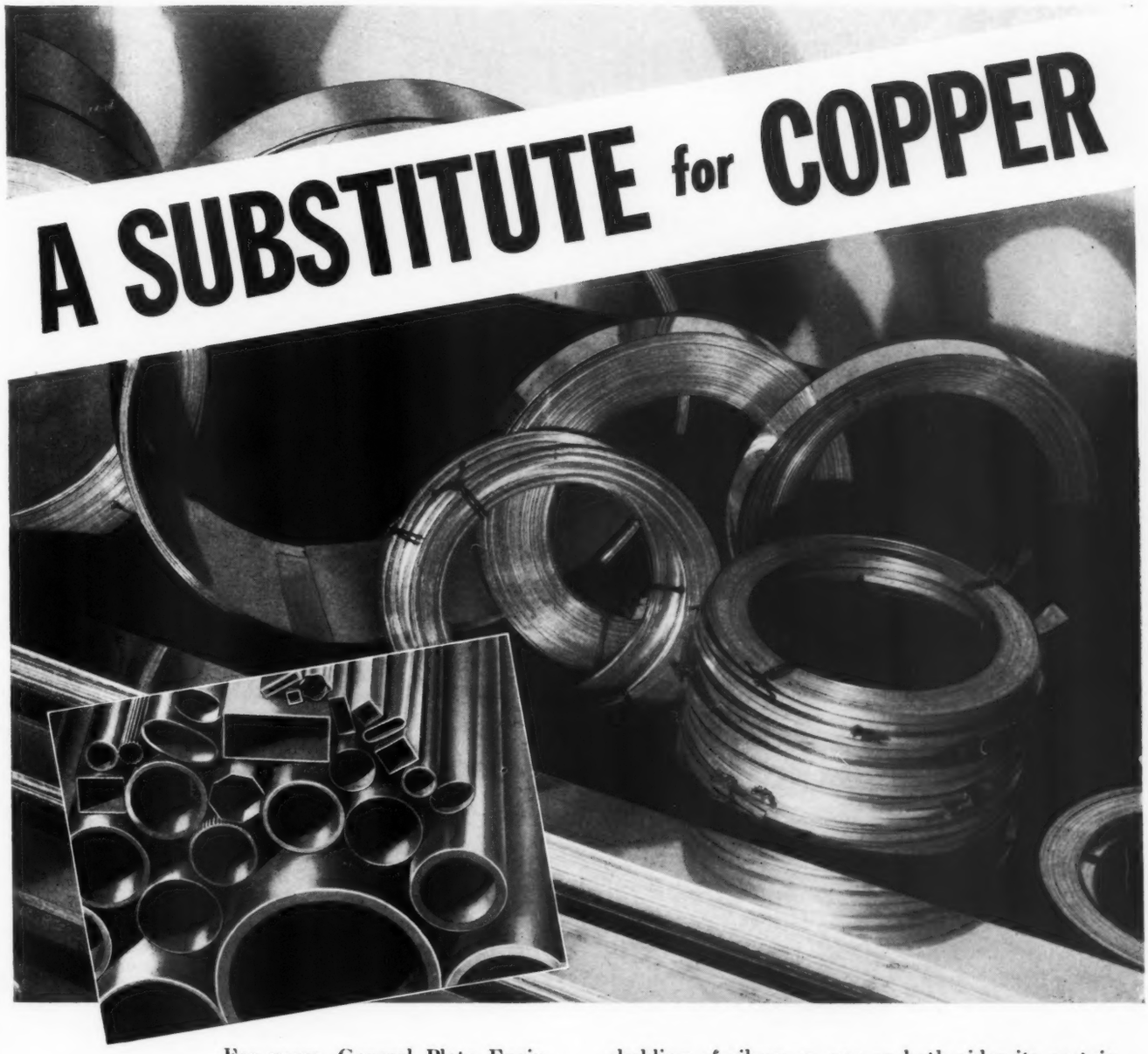
Troublesome Toggle Joints

Operation of a toggle joint stresses the machine frame. As the frame stretches, the toggle angle decreases; the resultant stresses consequently increase; the frame then stretches further. And so on. If the toggle joint is not properly designed, the toggle angle may reduce to zero, whereupon the mechanism may snap overcenter to a reversed position. How to design toggles so as to avoid such calamities will be described next month in "Design of Toggle Mechanisms" by Hans A. Illing.

Urea Plastics

If you have been saving your copies of PRODUCT ENGINEERING for the past several months, you have acquired a vast file of design data covering nearly every type of plastics—acrylics, acetate butyrates, cast and molded phenolics, laminated plastics, extruded plastics, polystyrenes, transparent plastics, plastics in automobiles, plastics in aircraft—to name a few. With the February PRODUCT ENGINEERING another article will be added to your files. Subject: Urea-Formaldehyde Resins.

A SUBSTITUTE for COPPER



For years, General Plate Engineers have developed special laminated combinations of metals to do unusual, specific jobs. And today, these laminated metals are life-savers for manufacturers who have difficulty getting metals vital to national defense. Many of these laminated metals are giving manufacturers the performance they need without using vital metals necessary for defense or with only the minimum use of metals hard-to-get.

For instance, General Plate makes a Silver on Steel Laminated Metal which makes a suitable substitute for copper. Due to its use of only a thin protecting cladding of silver on one or both sides, its cost is relatively low—also this cladding of silver provides rust protection. It comes in strips, coils, or wires in a wide range of thicknesses, widths, and gauges. It can be easily cut to meet your requirements—or, if you want special fabricated parts, General Plate will make them to your designs. Other metal combinations available.

If you have a metal problem, see if General Plate Laminated Metals can take care of it. Write, specifying your problems. Our engineers will give your request prompt and confidential attention.

General Plate Division

of Metals & Controls Corporation

Metals and Controls Corporation Divisions manufacture the following products: Laminated & solid precious metals, electrical contacts—Solid and rolled plated precious metals in all forms—Truflex Thermostatic Bimetals.

34 FOREST STREET, ATTLEBORO, MASSACHUSETTS

☆ For help in solving today's problems, Prominent Engineers thoroughly read the advertising pages in...
PRODUCT ENGINEERING

☆ "The advertisements in PRODUCT ENGINEERING are of prime interest and we look to them for the newest and best in modern equipment and tools. We have numerous subscribers to PRODUCT ENGINEERING in this division and it is the custom here to circulate the magazine within our organization, directing attention to the various advertisements and technical articles of most valuable interest to each other."

—H. J. Fleming, Engineer
Bendix Products Division
Bendix Aviation Corp.

☆ "I always look over the advertising section. On several occasions I have found items in this section that have proven very helpful either by finding a new source of supply or by discovering newly developed products.

"My opinion is that the advertising section has definitely been of value to me."

—J. Merck, Chief Engineer
Joy Manufacturing Co.

☆ "The advertising in PRODUCT ENGINEERING is of very great interest. For instance, it is seldom that an issue comes to hand that I do not send out for one or more folders or other literature describing products shown in this section of your magazine."

—H. G. Allen, Chief Engineer
Consolidated Packaging Machinery Corp.

☆ "To me the advertising is worth almost as much as the reading material."

—R. H. Weller, Chief Engineer
Booth Bros. Co.

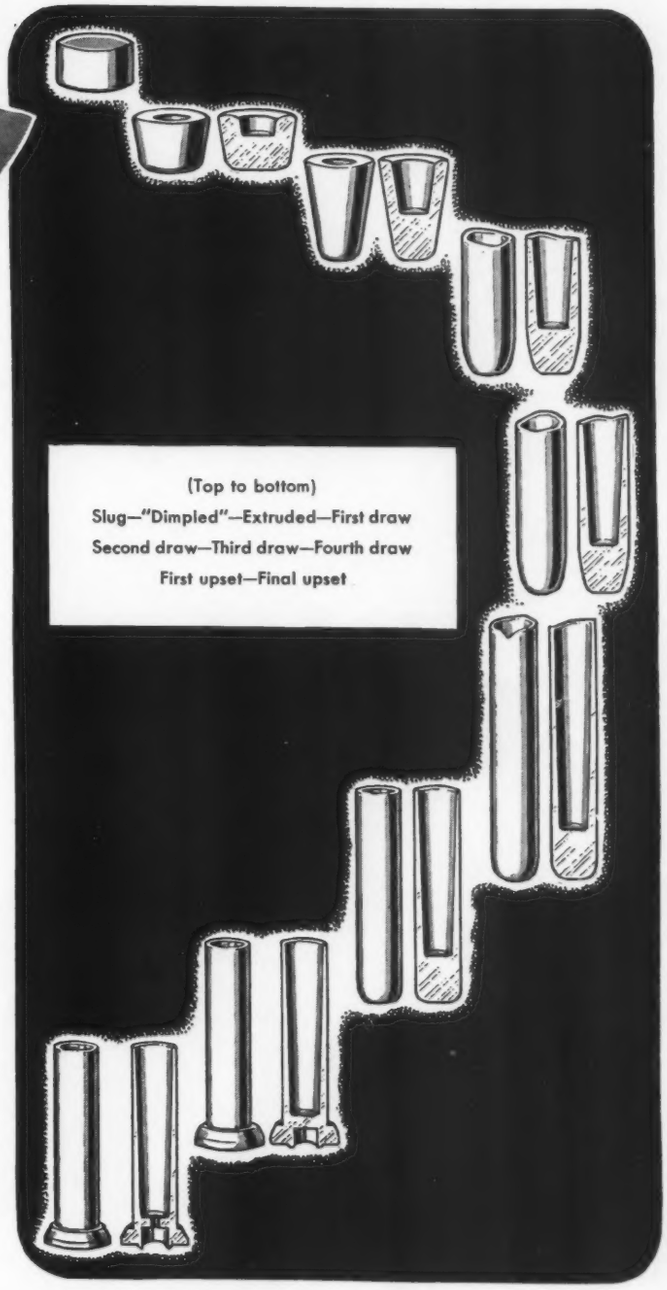
☆ "I read the ads first, then the rest of the paper at my leisure."

—A. H. Kruer
Platt Iron Works

☆ "I most certainly do read such advertising matter as applies to products that might have an application in our particular field. PRODUCT ENGINEERING in its present form is a very nicely balanced magazine and serves a very useful purpose in helping to keep our Engineering Department abreast of the times."

—R. L. Jewell, Chief Engineer
American Sterilizer Company

From "vanities" to primer bodies...



when Volupte and Revere put their heads together

When Volupte, Inc., one of the leading manufacturers of compacts, wanted to use its facilities to make primer bodies for Uncle Sam, the change-over involved more than merely a shift from beauty to utility.

Everything was new. Appearance had once been vitally important. Now performance took its place. Emphasis on surface finish gave way to emphasis on ductility, uniformity, precision. The brass had to be of a new analysis, responding differently to the various operations. New equipment had to be selected, and new methods worked out.

Here was a situation full of potential "headaches" for the manufacturer, but also full of opportunity for a Revere Technical Advisor to assist in eliminating them. After calculating a temper for the brass providing the correct balance between ductility and machinability, the customer was provided with a specification which made it easy to specify materials on repeat orders. A correct method was developed for each new operation. Recommendations on sizes of stock were made, to minimize scrap loss.

Quite some time has passed since Volupte, Inc. worked out these problems with the Revere Technical Advisor. America now has a large new source of dependable primer bodies . . . a prominent manufacturer has successfully added a new type of business . . . and Revere has helped an old friend. The Revere Technical Advisors will be glad to help you with your problems. Write us.

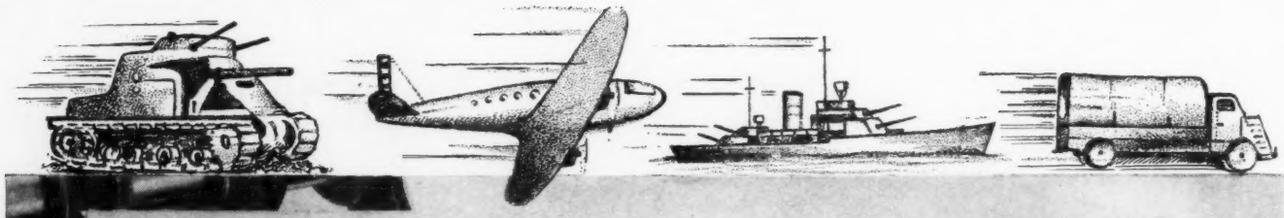
REVERE

COPPER AND BRASS INCORPORATED

Executive Offices: 230 Park Avenue, New York

Sales Offices and Distributors in most of America's major cities

MILLS: BALTIMORE, MD. · TAUNTON, MASS. · NEW BEDFORD, MASS. · ROME, N.Y. · DETROIT, MICH. · CHICAGO, ILL.



KEEP PRODUCTION ROLLING with MORSE ROLLER CHAINS

These great power transmitters pass along *all* the power of drivers to production machinery. No slips, no wasted power—Morse Roller "Channel-Lubricated" Chain drives deliver power with constant efficiency. They're rugged, long-lived, reliable. Worries about frequent maintenance or repair shutdowns end with the installation of Morse drives.

On many machines, in many plants, the change to Morse Roller Chain drives has boosted production to new highs, set new records for sustained productivity. First cost is low — maintenance costs are lower, due to the exclusive long-life features not available on less satisfactory drives!

Regardless of your chain requirements there is a Morse Roller to meet them, efficiently, economically. All sizes and capacities, single and multiple widths.

Call the Morse man. He'll help you look for places for profitable use of Morse Roller Chain Drives.

Oil gets in –
Wear stays out!
Heart of the Morse Roller Chain is protected with a life-preserving film of oil, flowing there through channels from the bushings. Oil gets in—wear stays out!

SILENT CHAINS ROLLER CHAINS FLEXIBLE COUPLINGS CLUTCHES

MORSE *positive* DRIVES

MORSE CHAIN COMPANY ITHACA N. Y. DIVISION BORG-WARNER CORP.

THE STORY OUR ADVERTISEMENTS DO NOT TELL

The advertisements of The New Jersey Zinc Company which are appearing currently in these pages explain the reasons why non-defense consumers have not been able to obtain all of the zinc they would like to have.

At the close of a critical business year, however, The New Jersey Zinc Company feels that it should tell a story which would not normally be a part of such a series of advertisements—a story of the cooperation given to this Company by its customers.

This cooperation, and the resulting exchange of vital information, made possible:

A better understanding of our mutual problems and difficulties;

The elimination of unreasonable demands and unfilled promises;

The fulfillment of contract obligations in spite of a tremendous expansion of business;

The shipment of a large list of zinc products where and when they were needed most—in defense and non-defense fields.

Consequently, thanks to our customers' cooperation and understanding, we feel that a difficult task has been accomplished.

The New Jersey Zinc Company looks forward to 1942 with confidence that this cooperation—which has proved of the greatest value under a heavy strain—will continue to operate to the mutual advantage of all concerned.

160 FRONT STREET

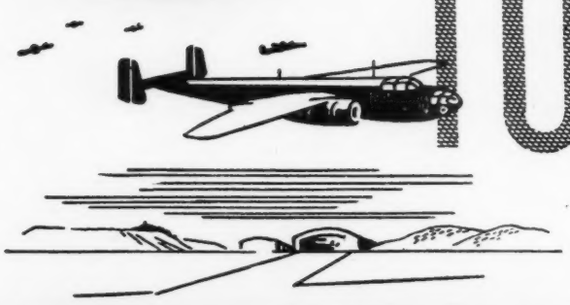
New Jersey Zinc

NEW YORK, N. Y.

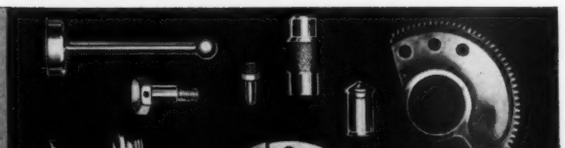
To help you get the most out of

STAINLESS STEEL TODAY...

more than corrosion resistance



If your plant is using Stainless Steel for defense work—your big problem is to push the work out faster—to avoid fabrication troubles—and to keep costs from getting out of line. Ever since the earliest days of Stainless Steel, Carpenter has been successfully attacking this problem. By developing the first bright finish, ductile Stainless Strip, and giving industry Free Machining Stainless Bars, Carpenter long ago paved the way for the precision jobs that men are turning out today. By cooperating on a wide variety of defense jobs, Carpenter is adding to the fund of experience and information that is available to all Stainless users. Ask us for fabricating information in easy-to-understand printed form that will help you speed up your production—and overcome trouble. A letter to us, or a phone call to our representative will promptly bring you the information you need.

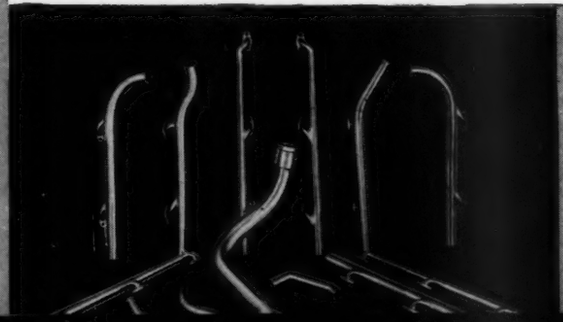


How about Hairline tolerances?

Many users of Carpenter Stainless are today working to almost unbelievably close tolerances on defense applications that we cannot even reveal. Such applications as these show the ability of this Stainless to meet super accurate requirements.

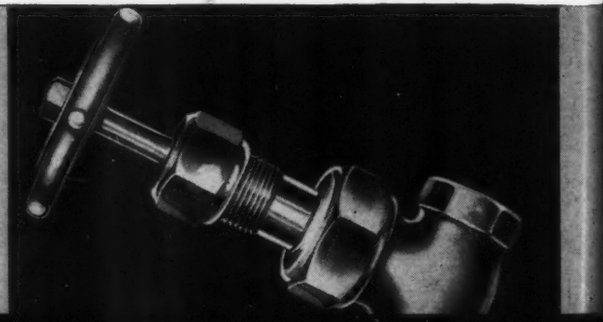
Will it withstand *Heat*?

Exhaust collector rings on giant bombers and transport planes glow red in flight. Carpenter Stainless is widely used to combat this and other heat conditions. A chart is available upon request that shows the heat resistance characteristics of various types of Stainless for high temperature service.



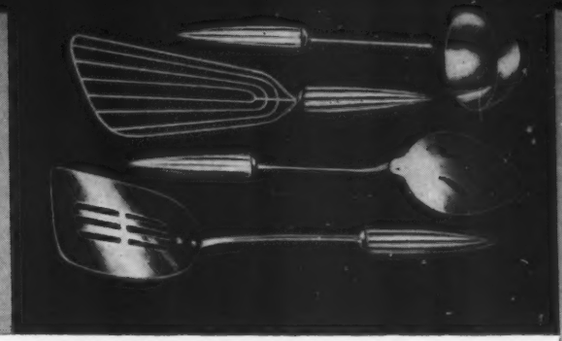
Is *Machining* a problem?

Not with the many manufacturers of valves, who use Carpenter Free Machining Stainless Steel. For suggestions to speed up production of parts requiring a lot of machining, ask for our data sheet on "Machining Stainless Steels."



Business Machines with fewer service complaints—

With parts like these made of Stainless Steel, typewriters have new sales appeal, particularly when they must operate in humid, tropical climates like South America. And the uniform temper of Carpenter Stainless means easy and quick production of intricate shapes, along with time saved on final finishing operations.



Low Cost Products from Stainless

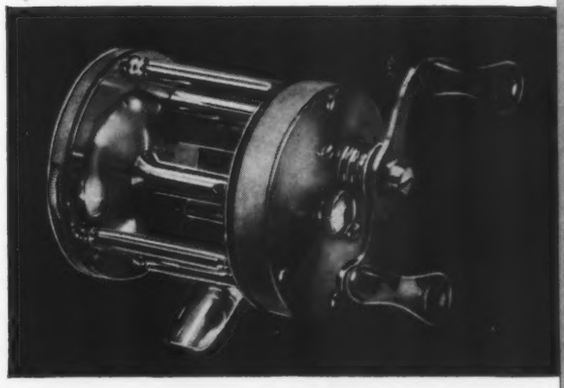
These kitchen utensils, sold in a highly competitive market, had to be given sales appeal along with strength and utility . . . so Carpenter Stainless was used. And manufacturing costs were held to 5 and 10c store limits by this easy-forming Stainless Strip.

TOMORROW

Out of the vast proving ground of national defense and wartime experience will emerge still better Stainless Steels. With them will come an improved "know how"—born of much problem-solving and many new fabricating experiences. Thousands of old products will "discover" Stainless Steel—many a product like yours will find improvement in appearance and performance with the use of Stainless in unexpected places. But don't wait until tomorrow comes! Start thinking and redesigning now and let us cooperate with you. There is no let-up in Carpenter research. We'd like to think ahead with you—give you the benefit of our experience and our new developments as they come along. Then when the zero hour on the sales front arrives, you'll be ready to uncover your new product, and get the jump on competition.

Smooth-Acting Parts = More Sales Appeal—

Like hundreds of other products, fishing reels must be smooth-acting, good-looking, and have that "pride-of-ownership" appeal. Moving parts must *always* work the way they should. Not only is the fabrication of parts easier, but Carpenter Stainless is also easier on tools and dies. When planning *your* future products, be sure to count all the advantages of this Stainless.



This handy Selector Slide Chart quickly suggests which Stainless analysis best meets your corrosion or heat resistance requirements.

To help you plan for *Tomorrow*—this Design Booklet will show you practical ways to make the most of the natural advantages of Stainless. A note on your business letterhead will bring you either of these Carpenter helps.

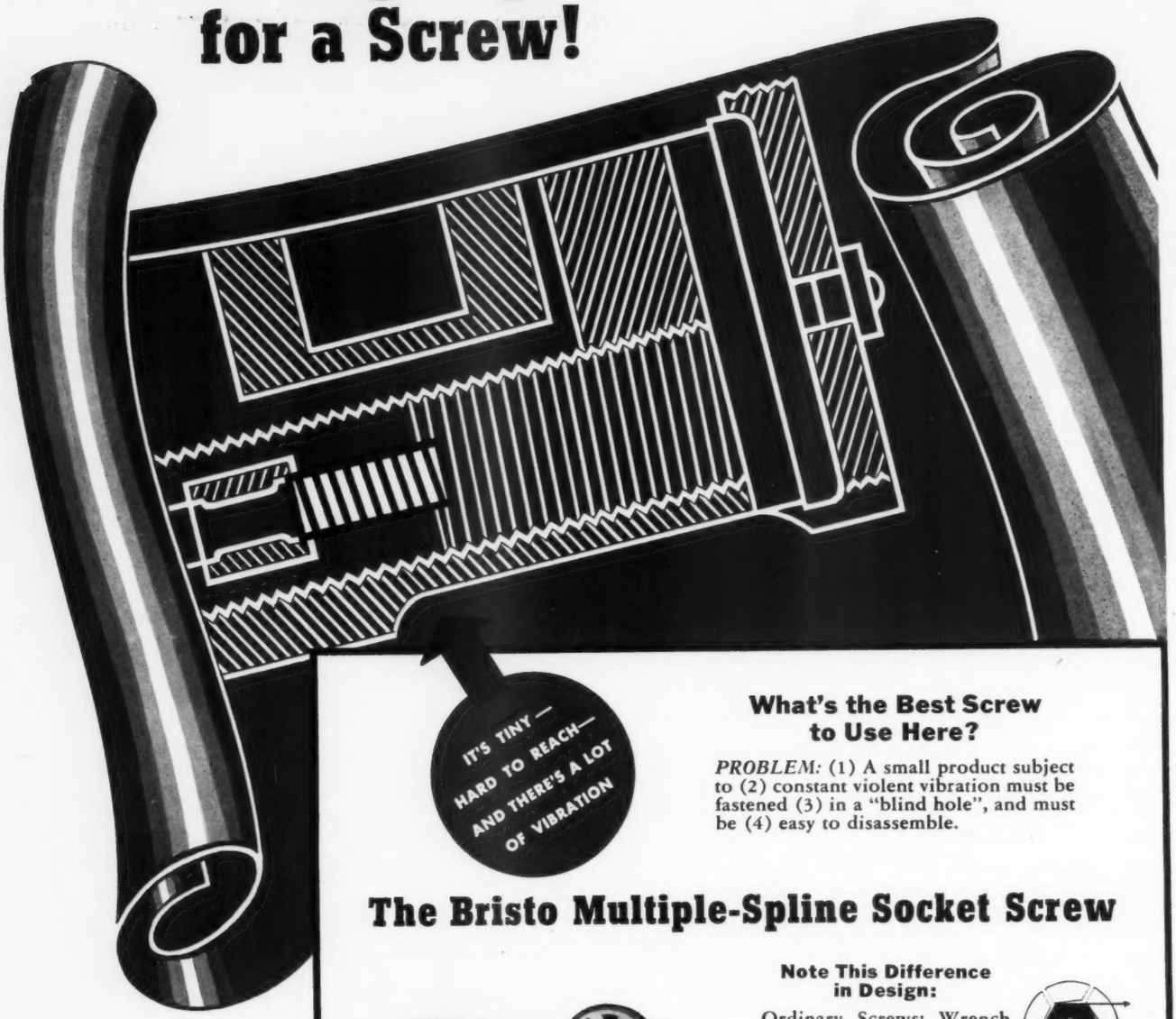
THIS OFFER GOOD ONLY IN U. S. A.

THE CARPENTER STEEL COMPANY, READING, PA.

Carpenter STAINLESS STEELS

BRANCHES AT Chicago, Cleveland, Detroit, Hartford, St. Louis, Indianapolis, New York, Philadelphia

A Tough Spot for a Screw!

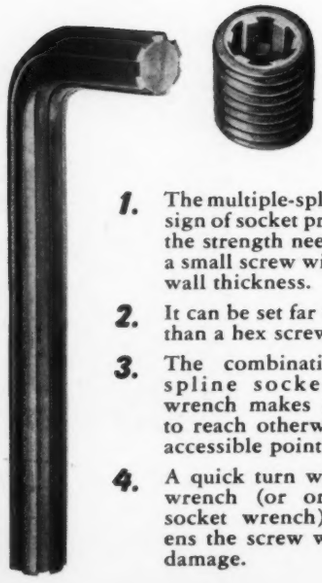


IT'S TINY — HARD TO REACH — AND THERE'S A LOT OF VIBRATION

What's the Best Screw to Use Here?

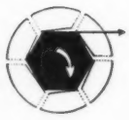
PROBLEM: (1) A small product subject to (2) constant violent vibration must be fastened (3) in a "blind hole", and must be (4) easy to disassemble.

The Bristo Multiple-Spline Socket Screw



1. The multiple-spline design of socket provides the strength needed in a small screw with less wall thickness.
2. It can be set far tighter than a hex screw.
3. The combination of spline socket and wrench makes it easy to reach otherwise inaccessible points.
4. A quick turn with the wrench (or ordinary socket wrench) loosens the screw without damage.

Note This Difference in Design:



Ordinary Screws: Wrench applies outward expanding force that is apt to round out or split socket wall.

Bristo Screw: Wrench exerts *contracting* pressure, for it is locked against the splines — no expanding pressure against walls.

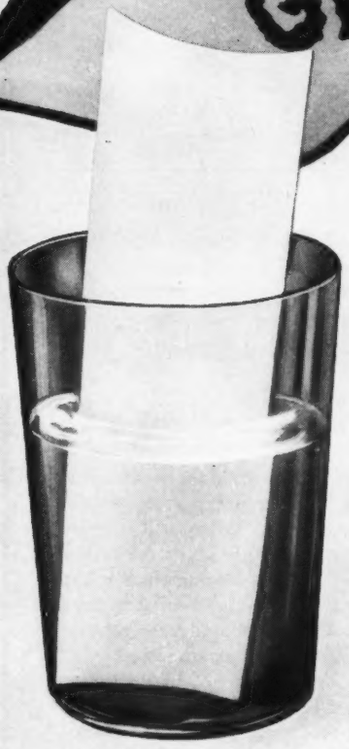
You Pay NO MORE for Bristo Multiple-Spline Screws

For small or large assemblies subject to vibration these screws are the perfect fastener. They give splendid service, for example, in electric refrigerators and fans, tabulating machines, oil pumps, electric razors, cameras, etc.

Made as small as No. 4 wire size. Wrenches are supplied *free* with each 100 screws. An ordinary socket wrench will remove them. Order from your distributor. And address 121 Bristol Road, Waterbury, Conn., for free sample screws, wrench and Bulletin 846.

The BRISTOL Company
MILL SUPPLY DIVISION
WATERBURY, CONNECTICUT

BRISTO MULTIPLE-SPLINE SCREWS SET FASTER — SET EASIER — SET TIGHTER



This new tracing cloth defies moisture stains and erasure scars

This new tracing cloth won't show perspiration stains or water marks—*holds pencil smudges and erasure scars at a minimum.* Now you can have clean tracings, in pencil or ink, free from these untidy "ghosts" that reproduce on blueprints!

For PHOENIX is ghost-proofed by a remarkable new process that defies moisture and gives you an unusually durable working surface. You can use harder pencils with this improved cloth and get sharper lines with less tendency to smudge. Even 6H lines show clearly, and reproduce sharply! Erasing does not mar the drawing surface; erased areas take pencil smoothly—and ink without feathering. Its new white color and increased transparency give you excellent drawing contrast and produce strong blueprints.

Put PHOENIX through your own drawing board test. See your K&E dealer, or write for a generous working sample and an illustrated brochure.

K&E
Phoenix
REG. U.S. PAT. OFF.
TRACING CLOTH
for pencil *and* ink

EST. 1867
KEUFFEL & ESSER CO.
NEW YORK · HOBOKEN, N. J.
CHICAGO · ST. LOUIS · SAN FRANCISCO · LOS ANGELES
DETROIT · MONTREAL

PHOENIX DEFIES MOISTURE GHOSTS . . .

Perspiration and water splashes on ordinary tracing cloth create "ghosts" which reproduce on blueprints. PHOENIX Tracing Cloth withstands actual immersion in water for fully 10 minutes at a time! *Perspiration and water marks will not stain it!*

PHOENIX LESSENS SMUDGE GHOSTS . . .

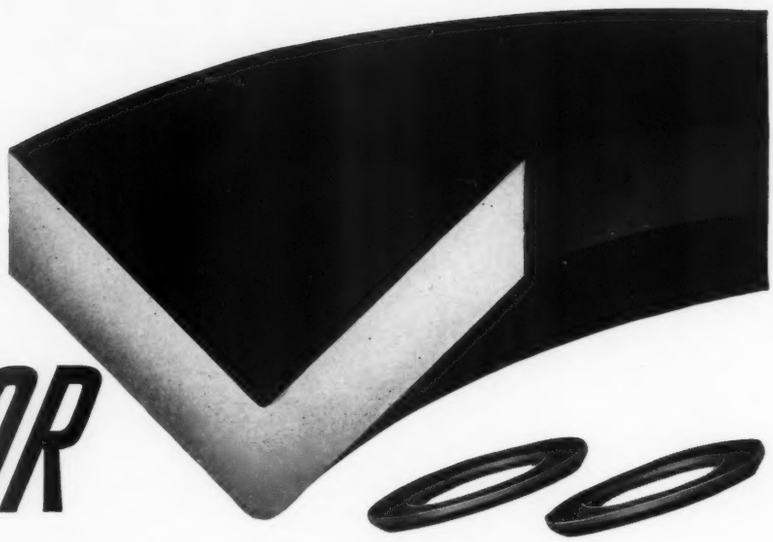
The new improved surface of PHOENIX Tracing Cloth permits you to use harder pencils (5H and 6H) and to get sharper lines with less tendency to smudge.

Result: Cleaner tracings and blueprints.

PHOENIX REDUCES ERASURE GHOSTS . . .

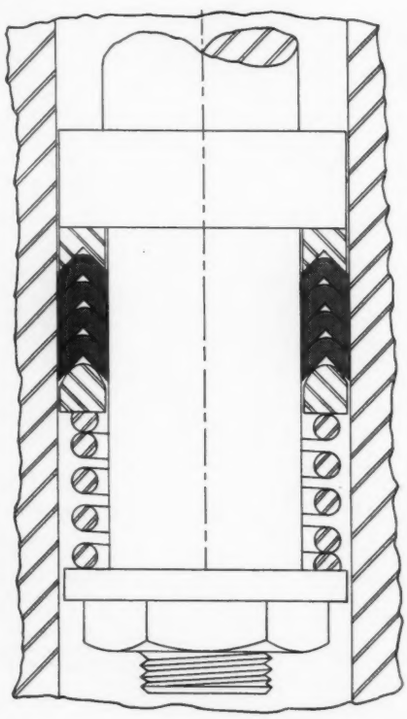
Ordinary tracing cloths become scarred when erased . . . erased spots produce ghosts on blueprints.

PHOENIX has a durable drawing surface that reduces working scars to a minimum.



VICTORY FOR

Spartan Leather Over Composition



Much longer service life results from Graton & Knight Vee packings because they are made from Spartan Leather, and each installation is thoroughly *engineered.*

These Vee packings, made with a dead 90° angle and fitted with proper adapter rings, will seal immediately with minimum pressure applied.

6 TO 1, LEATHER OVER COMPOSITION PACKINGS

V-shaped composition ram and pump packings were short-lived in a heavy duty hydraulic jack. Excessive tightening necessary to obtain an effective seal was causing rapid wear.

Graton & Knight engineers recommended replacing both sets of packings with Spartan Leather Vees, and using suitable metal adapter rings. Tension on the Vees was obtained by spring loading (see diagram), making it unnecessary to tighten the packings on either the ram or pump installations.

The customer reports: "To date the leather Vee ram packings have outlasted composition packings about six to one and have not yet failed. The Spartan packings on the pump have already run about 33⅓% longer than the composition and are still in service."

G & K IS BEST FOR V

G & K Vee packings, made from Spartan Leather, have accurate dimensions of thickness and diameters. The 90° angle gives the desirable 45° sealing lip, and the right combination of angles on top and bottom adapters provides the proper amount of spread on the Vee.

And for other types of packings — cup, U, flange or special — you can expect best service at the Packing Point from the combination of:

G & K engineering service. Call upon our engineers to help you determine the best design of packing, type of leather and treatment.

Spartan Leather. It has highest resistance to abrasion and heat, is unaffected by common pressure mediums, and will not dry out hard and brittle.

Spartan Packings

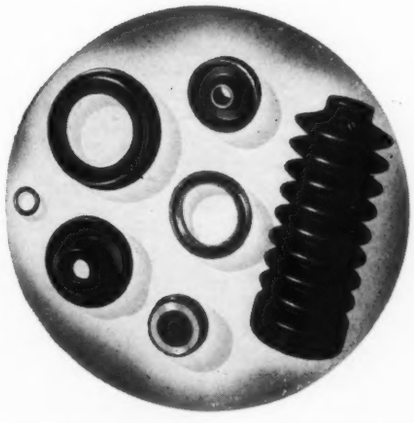
GRATON & KNIGHT CO.

WORCESTER GRATON AND KNIGHT MASSACHUSETTS

IMMEDIATE DELIVERIES!

At last! A rubber that maintains dimensions in oil

Hycar has amazing new resistance to all the products derived from petroleum, vegetable oils, fats, paint and ink driers. Articles fabricated from Hycar can be furnished to maintain desired dimensions in gasoline or oil and retain resistance to abrasion in the presence of these petroleum products.



Now you can have real precision molding

Hycar can be calendered, molded, extruded and otherwise fabricated on the same machinery as natural rubber and finished articles can be furnished to exact dimensions.

All you want of this better product

• If you're using rubber or certain synthetics in your product, chances are you're having trouble getting them. Or maybe you're looking for a synthetic that will do your job better. Now you can answer *both* these problems by asking your rubber supplier to make your product with Hycar, the new, improved synthetic of thousands of uses.

In laboratory and field tests, it has proved itself superior to one popular synthetic in 15 important ways, superior to another in 10 ways. In 12 of its properties Hycar shows superiority even to natural rubber!

Because Hycar is manufactured in a plant recently enlarged to produce twice its former capacity, this versatile material is available to your rubber supplier for immediate delivery in abundant quantities. Because Hycar is converted by an exclusive polymerization process from butadiene—a product of the American petroleum industry—it is completely independent of foreign sources of supply.

Substitute for scarce materials! Do you have a problem in materials for corrosion-resistant pipes, tubing, vibration dampeners, flexible hose or similar parts? It's entirely possible our engineers can help your supplier of rubber products solve the problem with Hycar.

Hycar can be made in any desired hardness, soft to bone-hard, beautifully colored and grained, and requires only standard rubber molding equipment.

For real proof ask your supplier for samples made of Hycar. Our engineers will be happy to cooperate with him.

Investigate Hycar for all uses where extreme resistance to petroleum products, to heat, cold-flow and abrasion is essential in a resilient material.

FOR OIL INDUSTRY	FOR AVIATION INDUSTRY	FOR MACHINERY INDUSTRY
Refinery	Gasoline hose	Engine mountings
Loading Hose	Oil hose	Vibration dampeners
Packings	Extruded parts	Oil seals
Distributor	Door and window seals	Gaskets
Gasoline pump hose	Sealing rings	Diaphragms
Cargo hose	Grommets	Rod-packing
Nozzle tip or tube		

Send for Samples and Prices

HYCAR

CHEMICAL COMPANY • Akron, Ohio

"Honey, here's the Xmas Gift I want IN NINETEEN-FORTY-UMPH!"

YOU KNOW MY SAD OLD KITCHEN. I had just about decided it was hopeless to do anything about the "open plumbing," the musty old closets, the funny old sink. Then last Sunday Jim and I visited a new "model house" and together we had a brilliant idea . . .

"ANYBODY CAN OWN A KITCHEN LIKE THIS," I told Jim. "That sink would just fit where our old one stands. We could buy steel cupboards like those. A new stove like that. New linoleum and new . . ." "Wait a minute —where does the money come from?" Jim interrupted. But I had the answer to that too.

"IN MY CHRISTMAS STOCKING you're going to put a very special present—for me from you. Know what it is? A U. S. Defense Bond. I'll give you one too. They'll be part of our new kitchen. Little by little we'll put away more U. S. Bonds and some day—sooner than we think, maybe—these bonds will pay for our dream kitchen."

LOOK FOR THIS LABEL

It's your promise from the maker of any steel product that he has taken care to give you the right quality of steel. Whatever the label's color or style, the initials—U · S · S—mean just one thing—manufactured from United States Steel.

MANUFACTURED FROM USS STEELS — UNITED STATES STEEL SUBSIDIARIES

Gifts we've promised to give ourselves

I want smart, modern steel casement windows. They let in lots more air and light, clean so easily. And I want the kind with built-in screens, so we won't be lugging screens up and down stairs twice a year.

Fresh idea worth saving...get more light with steel area walls. They don't settle or crack, so they stay seep-proof and trim. Shoo away that old rust bogie man by using U·S·S Galvanized Copper Steel.

Novel sink for my next kitchen will be this patent sink that disposes of every crumb. I'll be able to wash and dry my dishes without even wetting my hands. P.S. Made with U·S·S Vitrenamel.

UNITED STATES STEEL

CARNEGIE-ILLINOIS STEEL CORPORATION · *Pittsburgh · Chicago* · COLUMBIA STEEL COMPANY · *San Francisco* · TENNESSEE COAL, IRON AND RAILROAD CO., *Birmingham* · UNITED STATES STEEL EXPORT CO., *New York* · SOUTHWESTERN STEEL AND SPRING CO., *Chicago*, Warehouse Products Co., *Chicago*, Warehouse

"What's the idea of making people want what they can't get?"

THAT'S a fair question to ask. Probably it popped into your mind when you read the advertisement opposite that recently appeared in the Saturday Evening Post and other national magazines. If you haven't seen it before, take just a moment and read it now, won't you? It's important to *you.*

If you manufacture steel products it is only natural that you wonder why we seem to push such products when everyone knows they're going to be harder and harder to get.

Well, here's exactly why. It is because we want people to want products made of steel even though they may be increasingly difficult to buy—and to *keep on* wanting them, so that they will go out and buy such products when they again become easily available.

Because we believe that advertising like this is nothing less than *prosperity insurance* for the future—both for you and for ourselves—we plan to continue it.

For, one of these days when the clouds roll by, the production of simple, everyday things like paring knives and flour sifters, refrigerators and kitchen cabinets will once again become the Nation's prime endeavor. Then you—and we—will be able to realize fully on the accrued benefits of this advertising that keeps fresh in the public mind the comfort and convenience that steel can bring to them—and that shows them what the U·S·S label means in giving them their dollar's worth in extra satisfaction.

So when you plan your product for the future—plan to make it of *U·S·S Steels.* Then, when the public sees your U·S·S label, you'll find that they are already partially sold on your product, whatever it is, even before you start talking.

We would like to tell you more about this. Write us.

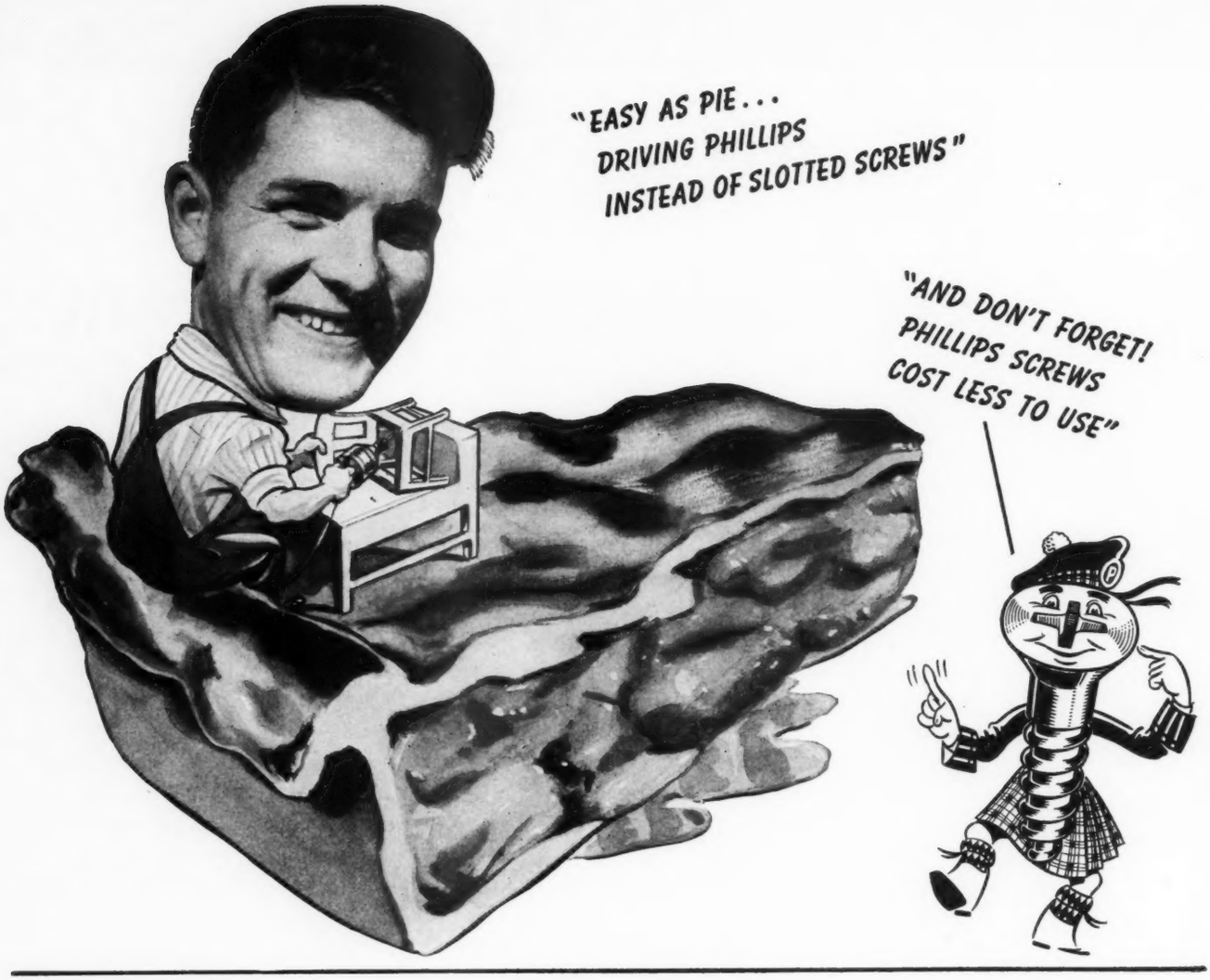
U·S·S National Advertising strikes new note

in the promotion of products made from steel. By the projection of buying into the future, it aims to keep alive the demand for these products. By emphasizing the U·S·S label as a symbol for steel quality, it provides additional sales support for any product bearing that label.

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*
Scully Steel Products Company, Chicago, *Warehouse Distributors*
United States Steel Export Company, New York

USS

UNITED STATES STEEL



Less Fatigue • Power Driving • Fewer Operations = 50% Less Assembly Cost with Phillips Screws

Yesterday — slow, painstaking slotted screw driving with plenty of muscle and plenty of care to see that the driver blade stayed in the slot. Plus plenty of time per assembly charged on the cost sheet.

Today — fast driving with the Phillips Screw that clings to the driver and prevents driver slippage. Faster driving methods are safe — more jobs where electric and pneumatic drivers can be employed. In the average case, Phillips Screws cut assembly time *in half!*

Add up the savings—this 50% reduction in time, the better work done by men less fatigued, the elimination of extra operations (including refinishing scratched surfaces), the freedom from crooked screws and split screw heads—you'll find you have a 50% saving in assembly *cost* as well as valuable assembly *time*.

Please your men and your cost accountant by changing to Phillips. They are easy as pie to drive — and make every assembly dollar do twice the work.

Any of the firms listed below will tell you more.

PHILLIPS RECESSED HEAD SCREWS

GIVE YOU *2 for 1* **(SPEED AT LOWER COST)**

WOOD SCREWS • MACHINE SCREWS • SHEET METAL SCREWS • STOVE BOLTS • SPECIAL THREAD-CUTTING SCREWS • SCREWS WITH LOCK WASHERS

U. S. Patents on Product and Methods Nos. 2,046,343; 2,046,837; 2,046,839; 2,046,840; 2,082,085; 2,084,078; 2,084,079; 2,090,338.
Other Domestic and Foreign Patents Allowed and Pending.

American Screw Co., Providence, R. I.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
The Charles Parker Co., Meriden, Conn.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterbury, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

Advertisement

JANUARY, 1942

COPPER ALLOY BULLETIN

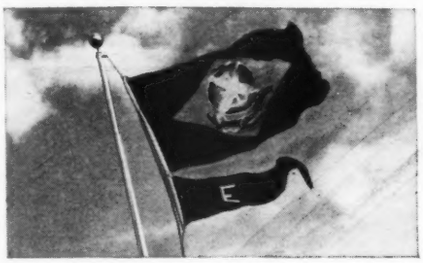
REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by the Bridgeport Brass Co. "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Navy "E" Flag Awarded To Bridgeport Brass

In recognition of "distinguished service in production" symbolized by presentation to the Navy of the 25,000,000th artillery cartridge case produced by Bridgeport since January 1940, the coveted Navy Ordnance Flag with "E" Pennant was awarded on Navy Day to the Bridgeport Brass Company by the U. S. Navy.

Although used by the Navy since 1906 as



a mark of special recognition for excellence in gunnery, battle practice, or engineering, the "E" has been awarded only to Navy personnel until this year. However, with emphasis today on production in the Nation's defense program, the Navy has awarded its "E" Pennant, together with the Navy Ordnance Flag, to certain manufacturing plants which have performed outstanding services in swift production of armament to the exacting Navy standards.

Memos on Brass—No. 24

Parts with excellent physical properties can be fabricated from brass forging rods when the production involved is sufficiently high to justify the cost of the special tools necessary. Hot forgings have several important advantages over castings—they are more than twice as strong, freer from porosity, more precise in dimensions, and have a smooth, clean surface.

Spinning Economical For Small Quantities

The spinning process frequently offers economies in time and production costs in the fabrication of small quantities of parts, for which high tool costs are not justified. Spinning tools can be made more quickly than those needed for stamping, and are more readily adaptable to various gages of metal. Copper, brass, and bronze can easily be formed by the spinning process, which has been applied to metal thicknesses up to ¼".

Knowledge of Regulations Speeds Inspection on Defense Orders

Unnecessary Delays Can Be Avoided by Clear Understanding Of Inspection Procedure and Method of Ordering Materials

With the prospect of ever-increasing defense activity ahead, fabricators who understand the type of government specifications, know who is responsible for inspecting various materials, and know how to make out orders that meet all of the regulations, will save both time and money.

While there are other agencies or divisions with their own set of specifications, Government specifications can be grouped into three general types—U. S. Army, U. S. Navy, and U. S. Federal.

Army Inspection

The U. S. Army has eight supply arms and services: Ordnance, Air Corps, Quartermasters, Signal Corps, Chemical Warfare, Corps of Engineers, Medical Corps, and Coast Artillery Corps. Although each one has its own inspection division, inspections may be made where feasible by any one or more of the other departments.

Each Army branch has its own specifications. If so stated on the Government contract, however, material may be inspected to specifications of other departments. Included in the list of other specifications which may be used are Federal specifications or specifications of the Government Arsenal involved. Recently, joint Army and Navy specifications have been issued prefixed by the letters AN, for aircraft materiel.

On U. S. Army orders, the fabricator should send a sufficient number of copies of his order to his local Army District Office, as they may direct.

Navy Inspection

The main divisions of the U. S. Navy are The Bureau of Ships, The Bureau of Aeronautics, The Bureau of Medicine and Surgery, The Bureau of Yards and Docks, The Bureau of Ordnance, and The Bureau of Supplies and Accounts. Although The Bureau of Supplies and Accounts is the centralized purchasing division for the Navy, each of the others has control of the materials bought for it.

Unlike the Army, inspection for all Navy divisions is made by one agency, the Inspector of Naval Materials. While they may be inspected to other Government or commercial specifications, all Naval materials will probably be inspected to U. S. Navy specifications.

On U. S. Navy orders, the fabricator must send four copies of his order to his local Naval District Inspection Office. This makes it possible for the proper papers to reach the Mill's local Naval District Inspection Office so that inspection can be made.

Complete Information Should Appear On Fabricator's Order

When material is ordered to any Government specifications or for Government use to a commercial specification, the fabricator's order should show:

1. Original contract and subcontract order numbers.
2. The Government division it is for, such as Army, Navy or other Government agency.
3. The Government specification number and date.
4. Grade, composition, class, type, and temper of material (if shown on the specification).
5. Place of inspection, such as:
   a. "Inspected at the Mill producing the material" or
   b. "Inspected at destination" or
   c. "Furnish certified reports of chemical and physical test to the specification involved".

Strong, Durable Parts Made With Duronze III

Strength, light weight, and corrosion resistance are three of the characteristics of Duronze* III that are bringing advantages to the design and manufacture of many parts.

50% stronger and 9% lighter than ordinary brass rod, Duronze III possesses the equivalent strength of many steels. This silicon aluminum bronze alloy is harder than most other non-ferrous alloys, yet has the advantage of being quite free machining. It is highly corrosion-resistant to fuel oils, exposure to the elements, sea water, dilute acids and other chemicals.

Because of this unusual combination of properties, Duronze III is widely used in the making of wire and cable connectors for outdoor use, oil burner nozzles, aeroplane, ordnance and high strength screw machine parts. For further details on this new alloy, write for Bridgeport's special Technical Bulletin on Duronze III.

COPPER ALLOY BULLETIN

ALLOYS OF COPPER

This is the thirtieth of a series of articles on the properties and uses of the copper alloys.

ELECTRICAL APPLICATIONS OF COPPER ALLOYS

During the past few months the alloys of copper and tin have been briefly discussed. In the November article mention was made in the table of the alloy containing only 1.8% tin. In addition to this alloy there are two other alloys which are of interest primarily because of their electrical conductivity. Reference to the October article indicates that the 1.8% alloy has an electrical conductivity of somewhat less than 40% that of copper. When the telephone lines came into general use at about the turn of the century search was made for an alloy of greater strength than copper and of as good conductivity as possible. As a result of this search the above alloy was developed and gained considerable use for telephone line wire. This alloy is still used widely for telephone drop line wire from poles to homes.

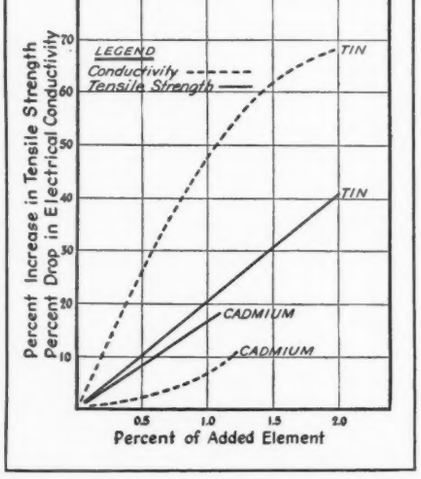
Phono Electric Wire

With the development of the street railway another need arose involving high conductivity and good strength. From this need came two other alloys containing about 1.25% tin in one and 0.4% in the other. These two alloys were known for many years as Phono Electric Trolley Wire and have been used where the service requirements have been most severe. Because of their excellent service records these alloys have been used for other purposes in which good conductivity, strength, ductility and corrosion resistance are essential. The alloy containing 1.25% tin has been used generally for electrical railway overhead hardware, for moving parts of electrical meters and for flexible corrugated tubing.

Additions of Cadmium

In more recent years additional alloys have been developed for trolley wire. These alloys are based on the addition of cadmium to copper. One of these alloys combines cadmium with tin to produce an alloy slightly higher in conductivity than the 1.25% tin alloy and of about the same strength. Another alloy is of cadmium and copper and is of considerably higher electrical conductivity. These two new alloys and the original copper-tin alloys are now recognized as standard trolley wire materials used where copper does not have the necessary strength and hardness.

The copper-cadmium alloys have also found use in a new industry within recent years, as contact joints for spot welding equipment. The requirements of this use are high electrical and thermal conductivity and good tensile strength and hardness. All of these alloys are useful in this respect, but the best combinations of conductivity and strength are found in the cadmium alloy. While alloys of higher strength are obtained in the copper-tin-cadmium alloy, the electrical and particularly thermal conductivity are not sufficiently high for this use. The accompanying graph illustrates the relative effects of tin and cadmium separately on the physical properties.



Effect of addition of tin and cadmium on the tensile strength and electrical conductivity of copper.

Brass Embossing Dies Described as Durable

Half-hard engraved brass embossing dies will give long life in embossing designs and lettering into very thin soft brass, copper, zinc, tin, aluminum, terne plate fiber, leather, name plates, tags and book covers, according to a manufacturer's announcement.

When used, the male die is screwed to a die shoe and the female die to a holder in the ram of the press. At each stroke of the press, a complete embossing results. Assembly may be made in any punch press and several interchangeable sections may be assembled for use at one time.

NEW DEVELOPMENTS

A rapid slide tool designed to hold small boring bars and forged cutters in turret lathes. Movement of the lever on the top of the unit transmits a rapid, smooth motion to the slide, thus permitting back-spacing and recessing operations to be quickly performed, it is claimed. Adjustable stops are provided for quick setting in performing duplicate work operations. **(No. 280)**

A new polishing rouge supplied in stick form for application on a polishing wheel to brass and copper has been developed. It is packed in small lots to 25 pounds, in cases containing 70 to 90 pounds and in drums containing 450 to 500 pounds. **(No. 281)**

A tool vise constructed on a double-cradle principle, which permits adjustments to grinding angles in three separate planes, is designed for grinding, chip-breaker grooves and tips of carbide tools. This vise has a base which can be easily mounted on a machine table. **(No. 282)**

A small offset boring head is now available. A special feature of this head is the retaining ring over the complete assembly, which assists in carrying the load on the tool-carrying block and helps exclude chips from the micrometer mechanism. Thus round type construction is said to be possible without introducing unsafe or hazardous features. The head has a 2-inch body diameter with an over-all head length of 1⅝ inches and an offset of 5/16 inch. **(No. 283)**

An internal thread grinder which automatically grinds threads up to 5 inches in length within a distance of 15½ inches from the spindle nose. The maximum hole ground is 9½ inches with minimum size of one inch. Maximum swing is 10 inches. A taper attachment is available which allows grinding up to a maximum of four inches in diameter per foot on effective thread length. **(No. 284)**

A grinding wheel dresser said to give performance comparable to that of a diamond dresser is now on the market. The wheel is held in a protective metal housing which deflects grindings away from the operator. The cutting wheel is replaceable. Besides general cleaning and truing of grinding wheels, other uses include truing of cut-up and uneven sides, dressing out deep grooves and out-of-roundness and restoring out-of-balance wheels to true rotating ones. This tool can also be used to shape wheels into different forms when form grinding is desired. **(No. 285)**

A clamping unit, constructed of cast iron and steel, designed to hold work on machine table or in drill fixture. A lever arm actuates a plunger, moving it in and out of the cast iron base to a maximum distance of one inch. As soon as the plunger end strikes an obstruction, it locks in position and holds until the lever arm is reversed. These units are made in a variety of sizes for numerous clamping and holding applications. **(No. 286)**

This column lists items manufactured or developed by many different sources. Further information on any of them may be obtained by writing Bridgeport Brass Company, which will gladly refer readers to the manufacturer or other source.

PRODUCTS OF THE BRIDGEPORT BRASS COMPANY

Executive Offices: BRIDGEPORT, CONN.—Branch Offices and Warehouses in Principal Cities

SHEETS, ROLLS, STRIPS—*Brass, bronze, copper, Duronze**, for stamping, deep drawing, forming and spinning.

CONDENSER, HEAT EXCHANGER, SUGAR TUBES—For steam surface condensers, heat exchangers, oil refineries, and process industries.

*Trade-name.

PHONO-ELECTRIC* ALLOYS—High-strength bronze trolley, messenger wire and cable.

WELDING ROD—For repairing cast iron and steel, fabricating silicon bronze tanks.

LEDRITE* ROD—For making automatic screw machine products.

BRASS "Bridgeport" CO.

Established 1865

COPPER WATER TUBE — For plumbing, heating, underground piping.

DURONZE ALLOYS — High-strength silicon bronzes for corrosion-resistant connectors, marine hardware; *hot rolled sheets* for tanks, boilers, heaters, flues, ducts, flashings.

BRASS, BRONZE, DURONZE WIRE— For cap and machine screws, wood screws, rivets, bolts, nuts.

FABRICATING SERVICE DEPT.—Engineering staff, special equipment for making parts or complete items.

BRASS AND COPPER PIPE—"Plumrite"* for plumbing, underground and industrial services.

BRIDGEPORT BRASS

What Can I Do?

EVER SINCE that Sunday morning when havoc swooped from the skies upon Honolulu, a new question has been churning about in millions of American minds. It is this: What can I do to help my country win this war?

This insistent question has pushed aside all matters of personal interest. From now on, individual wants and wishes must give way to the paramount needs of the nation. We all accept that. We have undertaken a huge job. Or, I should say, we have had a huge job thrust upon us. And unless we see that job through successfully it won't much matter what any of us may want.

That job is to win this war.

No longer are we trying to prepare for a war that we may get into. Today we are trying to win a war we're already in—and in up to our eyes. Nothing that any one of us now can do to help himself can get him very much if it does not also help our country to win this war.

I am sure that those who read these words will find many things to do. Some will enlist in the armed services. Some will become active in civilian defense. Some will labor to relieve distress in their home towns. Some will work with organizations set up to serve the men at the front. Each can and will find something he can do.

But this insistent question "What can I do?" goes beyond the individual and his personal service. It reechoes through the offices and the shops of every American business concern. And what I have to say here is not directed toward individual effort. Rather is it intended for the men and women of American industry who make that industry a living part of American life. Today they are asking themselves: What can industry do? Or better still, what *must* industry do if our country is to finish the job it has started?

Those of us who work in and with American industry have one supreme obligation. We may feel very patriotic; we may be willing to serve "in any capacity;" we may be willing to sacrifice . . . if necessary. But if we fail to meet that one obligation, we shall fail our country in its time of need.

THAT SUPREME OBLIGATION IS AN HONEST DAY'S WORK, EVERY DAY, FROM EVERY MAN, EVERY WOMAN, EVERY MACHINE. . . .

IT IS AS SIMPLE AS THAT!

And that goes for all of us, whether we are engaged in civilian production or working directly on the weapons of war. American victory can be won only through the productivity of American industry.

Efficiency in production is not the responsibility of a few. It can be achieved only as we all put to useful purpose every minute of our time, every ounce of our energy, and every pound of our materials.

This responsibility of industry is the more vital because of what has happened to the business of making war. There was a time when success in war was chiefly a matter of well-trained, well-disciplined armies and competent leaders—when men were everything. In those days, military strength was a matter of strong battalions and able generals. Both still are vital. But today military might is essentially mechanical might. Modern war is an industry just as much as a factory or a railroad. In the first World War, mechanical equipment was relatively simple and limited. But today the special equipment of war and the expert skill needed to use it spell the difference between victory and defeat.

We Americans are not expert war-makers. That is why we must expect to suffer grievous losses before we can win substantial gains. We do not have military training and experience ready to hand when we need them. Neither do we have, ready for action, enough of the machines that are so essential to modern warfare.

So, when it becomes necessary to fight for our lives, we must start from scratch. And today, after a year's effort, we still are not ready to trade blow for blow with enemies who for years have schooled their leaders, trained and disciplined their people, and organized their industries to make war. We shall need more time to develop our strength. And while we are doing that, we must expect reverses.

But there is a brighter side to all this. For it follows that if we are granted this all-important time, the change in the method of warfare is right down our alley. The greater importance of mechanized equipment plays straight into the hand of the world's greatest industrial nation . . . if there is one thing America *does* know, it is industrial production! Our industries know how to produce. They have the skilled manpower. They have the organized facilities. Beyond any doubt, we can produce all that we need to win the victory that we *must* win—if only we are given the time.

THE FIRST RESPONSIBILITY OF THE ARMED FORCES IS TO GAIN THAT TIME FOR US.

THE FIRST RESPONSIBILITY OF INDUSTRY IS TO USE TO THE FULL EVERY SECOND OF THAT TIME IN PRODUCING THE WEAPONS

THE ARMED FORCES NEED TO WIN THE ULTIMATE VICTORY. INDUSTRIAL PRODUCTION IS THE KEY TO VICTORY. BUT IT MUST BE BIGGER PRODUCTION AND FASTER PRODUCTION THAN WE EVER HAVE KNOWN.

Heretofore American industry has worked to produce more of those things which make our lives more enjoyable. Today it must divert much of its energy from the products of peace to the weapons of war.

This change sets up a new yardstick of industrial performance. In time of peace we measure production efficiency in terms of money saved. From now on, we must measure efficiency chiefly in terms of time saved. For the plane, the tank, the gun, or the ship that is ready when it is needed to win a victory, is worth a million times more than the one that is delivered too late to avert a defeat.

Everyone knows how short we are of some materials and machines. But our most tragic shortage is the shortage of time. So whatever we may waste in the days ahead—and unhappily we are bound to waste plenty—let us never forget that the most deadly waste of all is the waste of time.

Time wasted never can be replaced. No one ever has discovered a substitute for time. If we would avoid the waste of this irreplaceable ingredient of victory, we must use every minute of it effectively—*while we still have it.*

That goes for us all. It goes for the man or the woman at the bench, at the desk, at the counter, in the field, or in the executive office. It goes for the politician as well as for the business man. It goes for the humblest and the most powerful. A nation at war cannot carry deadheads. It cannot spare a square foot for any one who will not pull his weight.

In this war, nothing short of complete victory can save the liberties of us all, rich and poor, employer and employee, haves and have-nots alike. The price of that victory is the labor, the loyalty, and the devotion of every last one of us. Winston Churchill said it well for the British people. You know how he said it. I need not repeat it.

All this imposes upon American industry, its owners, its managers, and its workers, the gravest responsibility they ever have assumed. If our country is to survive as a free nation, American industry must rise to that responsibility. If our country should fall, it would fall because American industry fell short of the need. It would be another case of "too little and too late".

This grave responsibility calls for the keenest management industry ever has known. It calls for unremitting research to make the most of our resources. It calls for the reduction of waste to a record minimum: that goes for waste of time, labor, and material. It calls for keeping our machinery working as near to full capacity as we can contrive. It calls for the highest rates of unit production we ever have known. That will mean skillful coordination by management and the most intelligent cooperation that the men in the shops can give. It calls for inventive ingenuity to match that of a nation which has produced some of the world's outstanding technical genius. For this is a war of technical proficiency.

But above all, it calls for a new devotion to the day's work. For so long as we are at war, the day's work will determine our country's security.

Whatever may be our material resources and our technical skill, however resourceful our management, however broad the scale of our effort, industry cannot measure up to its prodigious responsibility if any of us shirk the day's work. Right there is where we find the one thing we *all* can do—the one thing that is within the power of each of us.

THAT ONE THING IS SIMPLY TO DELIVER AN HONEST DAY'S WORK WHEREVER WE ARE CALLED TO SERVE. HONEST WORK WILL WIN THIS WAR. LOAFING WILL LOSE IT. THE SHOWDOWN WILL BE WHETHER HITLER CAN DRIVE HIS PEOPLE TO WORK HARDER THAN WE ARE WILLING TO WORK. THERE IS NO ONE TO DRIVE US. WE MUST DRIVE OURSELVES!

Is that so much to ask? It is all our country asks of us, the men of industry. It is all that the men who must work the guns and tanks in the field ask of us. It is all that the men who work our ships and our planes ask of us. "Give us the planes, the guns, the ships, the tanks, and all the rest of our tools," they tell us, "and we'll give you the victory that means so much to us all. But, in the name of that victory, give them to us quickly—QUICKLY—QUICKLY!"

Is that, I repeat, too much to ask of us?

* * * * *

To help American industry achieve ever-higher standards of efficiency has been the traditional mission of McGraw-Hill for three-quarters of a century. Normally that effort has been directed toward higher efficiency in the business of peace. But, as in the first World War, twenty-five years ago, it now is directed toward efficiency in the business of war and in every department of American effort that can contribute, directly or indirectly, to the achievement of victory.

And to that mission, I here pledge every resource of this company, its publications, its books, its staff, and every service it is qualified by experience and training to render to American industry, now enlisted in our common cause.

That is what we of McGraw-Hill can do. And that is what we *shall* do to our utmost.

James H. McGraw Jr.

President, McGraw-Hill Publishing Company, Inc.

This message is appearing in all McGraw-Hill industrial and business publications, reaching over a million readers.

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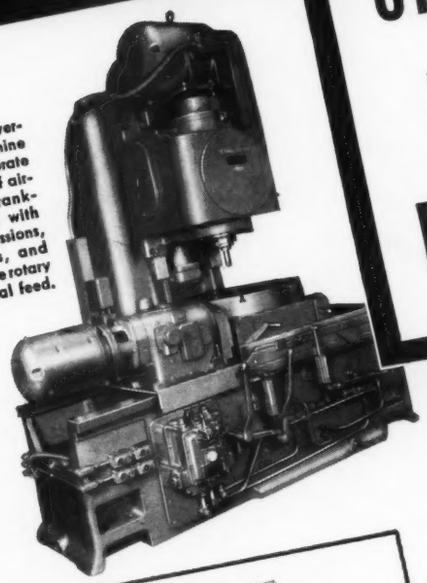
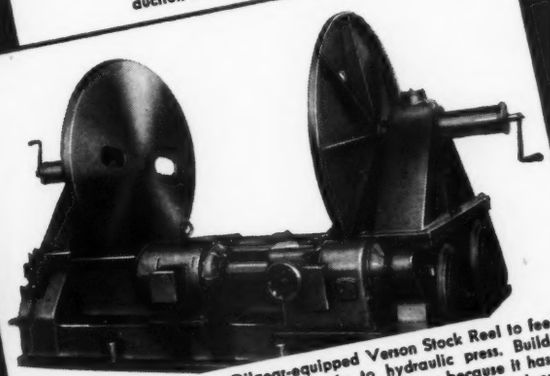
OILGEAR FLUID POWER HELPS YOU ANSWER *Vital* MACHINE DESIGN PROBLEMS



Davis & Thompson vertical milling machine for high speed accurate milling of inside of airplane engine crankcases. Equipped with Oilgear Transmissions, Pumps, Valves, and Cylinders to drive rotary table and lateral feed.

Five Oilgear Units in this Baker propeller-hub drilling machine perform 5 steps of drilling, facing, and chamfering to speed up propeller production for defense.



Oilgear-equipped Verson Stock Reel to feed cold-rolled strip to hydraulic press. Builder says: "We selected Oilgear because it has a range beginning at absolute zero and continuing up to maximum feed; also may be smoothly and almost instantly reversed."

FOR ease of power transmission application, for versatility of installation, for maximum production of your machines, for long, troublefree operation in the field . . . your best answer is Oilgear Fluid Power Pumps, Motors, Transmissions, Cylinders, and Valves. Note the varied applications of Oilgear shown on this page; they are a trifling few of the many tough machine design problems solved by manufacturers in many fields.

Oilgear Fluid Power Systems are compact, simple, easy to install. They present smashing advantages over mechanical drives and other hydraulic systems. They may be used with any kind of drive—belt, chain, gear, or direct—and require a minimum of piping and space. They offer a wide range of standard sizes and controls permitting you to custom-fit Oilgear Systems to the speed, power and function specifications of practically any machine. Speeds are steplessly variable from zero to maximum in either direction; ratios between feed and rapid traverse are high; feed speeds can be controlled with *micrometer* accuracy; reversals are fast, cushioned and controlled; lubrication is automatic with Oilgear Fluid Power Units. Pre-set operating speeds in either direction, remote control by push-button stations and automatic pressure unloading are a few of the advantages of the many different types of Oilgear standard controls.

The superior performance and dependability of Oilgear Fluid Power Systems have proved out on the toughest defense schedules. From your standpoint and your customers' it is the most economical and efficient answer to the power problems of your machines. Complete technical data is yours for the asking. Just indicate on the coupon whether you want information about Oilgear Pumps, Motors, Transmissions, Cylinders, Valves, or all of them. THE OILGEAR COMPANY, 1311 West Bruce Street, Milwaukee, Wisconsin.

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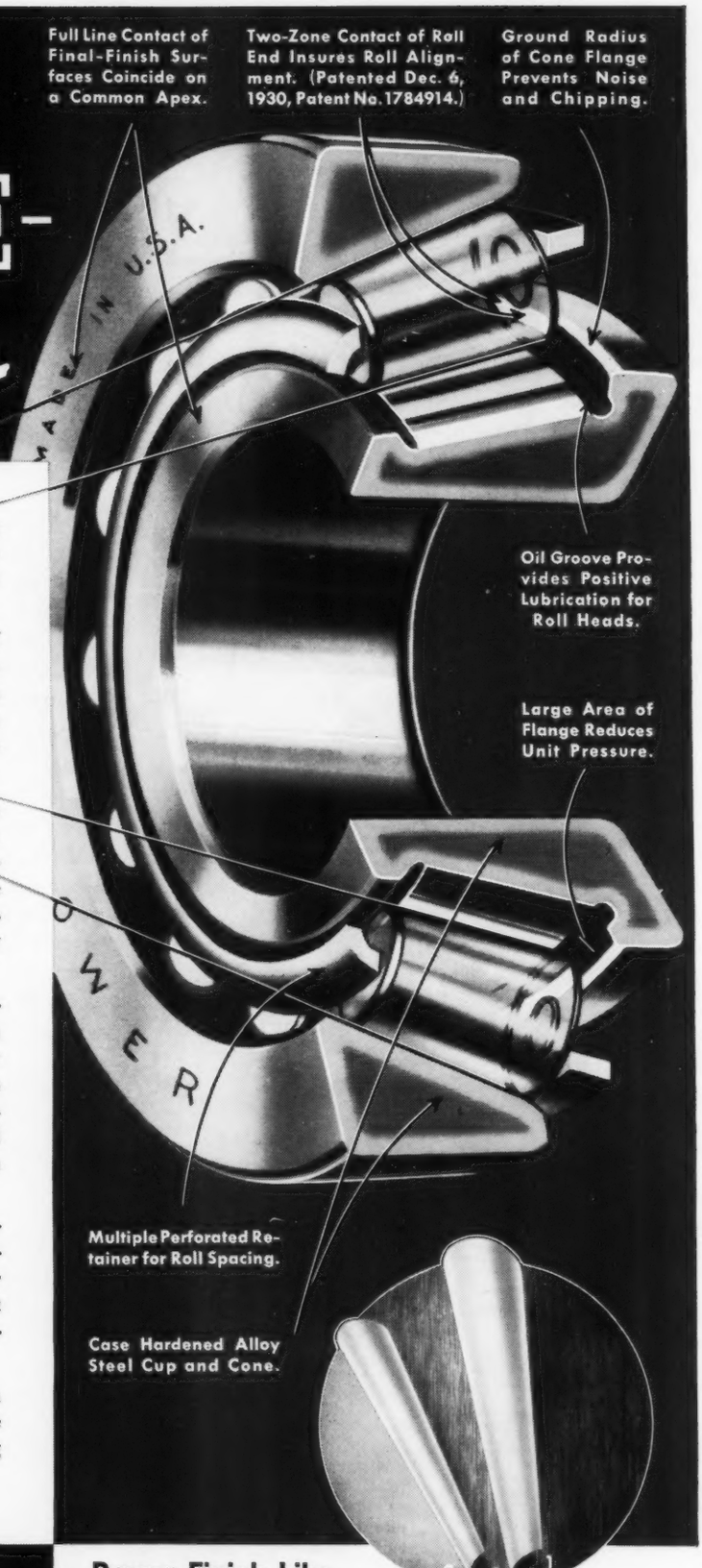
OF FIRST IMPORTANCE—

Design


Full Line Contact of Final-Finish Surfaces Coincide on a Common Apex.
Two-Zone Contact of Roll End Insures Roll Alignment. (Patented Dec. 6, 1930, Patent No. 1784914.)
Ground Radius of Cone Flange Prevents Noise and Chipping.
Oil Groove Provides Positive Lubrication for Roll Heads.
Large Area of Flange Reduces Unit Pressure.
Multiple Perforated Retainer for Roll Spacing.
Case Hardened Alloy Steel Cup and Cone.
MADE IN U.S.A.
BOWER
3
2
1

THIRTY-EIGHT years of Roller Bearing manufacture have proved that design is the most important element in a bearing.

Likewise, the use of many millions of Bower Roller Bearings as original equipment over a period of many years in America's leading large-production automobiles has proved the correctness of BOWER DESIGN.

Bearing users will appreciate that the exacting standards of the automotive industry and the severe usage of bearings in automobiles offer a challenge that no roller bearing can meet unless it possesses the highest degree of quality known to the bearing industry.

One of the secrets of Bower's leadership is the fact that its technical men have never waited upon the ingenuity of other men. Bower engineers push relentlessly ahead—far beyond the needs of the moment—to make new technical discoveries and to apply them always in ADVANCE.

This Tapered Roller Bearing is a leading example of Bower design. It embodies important advantages that no other bearing possesses—advantages that Bower engineers discovered and incorporated ahead of all others.

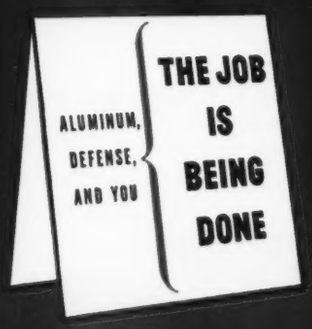
For more detailed information on Bower design, ask us for a copy of the folder, "Secrets of Bower Roller Bearing Design and Quality."

BOWER
ROLLER BEARING CO.
Detroit, Michigan

Bower Finish Like A "Face-Lifting" Operation

1. ROUGH GROUND—Photomicrograph—25 diameters—showing amorphous film with roughness of approximately 15 micro-inches (millionths of an inch). **2.** FINISH GROUND—More but finer scratches—surface finish of approximately 10 micro-inches composed of amorphous metal left by finish grinding—Photomicrograph of 25 diameters. **3.** FINAL FINISH—25-diameter photomicrograph showing amorphous metal and grinding marks removed, baring hard surface and smoothness of approximately 3 micro-inches—scratches below surface.

ALUMINUM, THE FUTURE, AND YOU



RIGHT NOW OUR FACTORIES have only one interest: to make more Defense Aluminum than the world has ever seen before. Every resource we can muster is concentrated on that job.

WHEN AMERICA HAS WON THROUGH to make the world safe for our children to live in . . . the saying is: What a lot of aluminum is going to be available for everybody.

THE REAL POINT TO PONDER is how to get set to make that deluge of light metal work for you. In the kind of world we're going to have, sure as fate, the man who fails to call, *now,* on every resource at his command is going to be left at the post.

WE'VE COINED A WORD:

IMAGINEERING. It's the fine art of deciding where you go from here. It's the act of thinking out what you are going to face, and doing something about it now. *Imagination* plus *engineering* is a formula for the future you're going to hear more about.

A MAN CAN be producing for Defense at top speed and be imagineering at one and the same time. In fact, the more he is devoted to Defense now, the more he needs imagineering for ***THE DAY WHEN.***

OBVIOUSLY, you can imagineer with steel, copper, glass, zinc, plastics, or what have you. We hope you will, because the world is going to need better use of all materials than it ever saw before.

THE CLOSER YOU GET TO FUNDAMENTALS the more quickly you must decide that the great need is going to be for the very things Alcoa Aluminum does best: Lightness with strength, resistance to corrosion, reflectivity, workability and all the rest of its powers all wrapped up in a low-cost package full of unlimited possibilities for you, personally, in your business.

TWO HEADS ARE BETTER THAN ONE. Already, many an industry, many a company, has called us into an imagineering session. We've seen things projected that will make news when the curtain can be lifted. Usually we've been able to help with some imagineering of our own.

DOES THIS SUGGEST ACTION? WE HOPE SO.

Aluminum Company of America, Pittsburgh, Penn.

ALCOA ALUMINUM

Hell-bent-for-election

THESE flying water-scats were designed almost beyond the power of men to control. As it is, the men must be heavily padded, lashed to their positions, to take the pounding of terrific speeds in rough weather.

Every part of these mosquito boats from gun to galley has been specified and manufactured to withstand the hard use that make the boats a powerful weapon of attack.

For rugged service in the heavy duty machines of war—and for delicate duty in the sensitive instruments of science go Barnes-made springs in endless streams from mass production lines, controlled by the engineering skill of veteran springmakers.

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DIVISION OF ASSOCIATED SPRING CORPORATION
BRISTOL, CONNECTICUT, U. S. A.

Barnes-made Springs *for Defense*

Ready to Give You TEAMWORK

American industry has learned to use so many forms and types of steel, and so many methods, that no one man, or group of men, knows them all.

That is why the Steel Castings Industry pools its knowledge and experience. Ideas and information, within the industry, are freely interchanged, for *your* benefit and profit.

Your own foundry can serve you better, by making available to you what the whole industry has learned of improved designs, methods, techniques.

Each month, ten technical and operating groups of production men, in major production areas, meet for discussion and exchange of ideas. These meetings permit the whole industry to share progressive ideas, technical information and research results.

That's teamwork.

Within the industry, foundries compete with each other. Each has a perfectly human desire to do more business. But they co-operate with each other too, to make the products of the industry worth more to you, in your business.

For information on how Steel Castings can help you improve or modernize your product, or reduce your costs, consult your local foundry, or write to Steel Founders' Society, 920 Midland Building, Cleveland.

STEEL CASTINGS

Bring You These 7 Advantages

1 *Uniform Structure* for strength and shock resistance.

2 *Metal distributed* for strength with minimum weight.

3 *Wide* range of physical properties.

4 *Good Machining qualities* — lower finishing costs, better appearance.

5 *High rigidity,* accurate alignment, minimum deflection, better fit.

6 *Readily weldable* in composite structures.

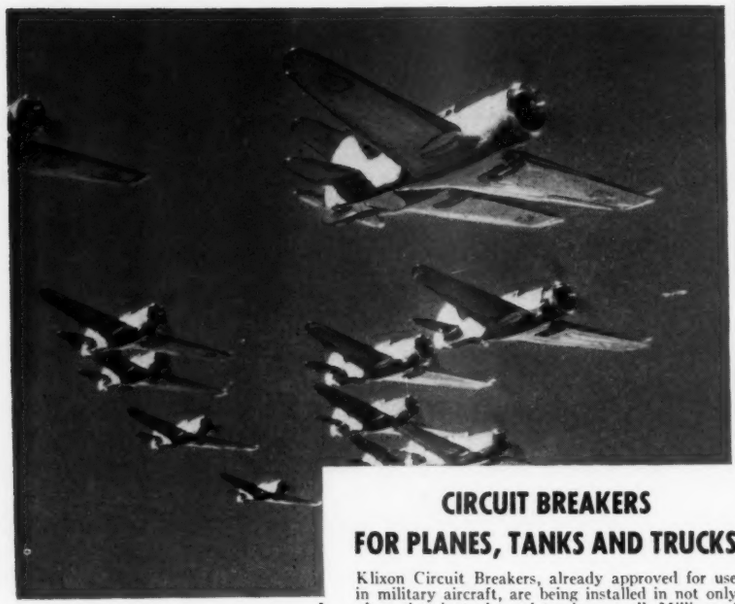
7 *High fatigue resistance,* longer life, ideal for critically stressed parts.

MODERNIZE YOUR PRODUCT WITH

STEEL CASTINGS

The SPENCER DISC has earned its wings

with these 4 Aircraft Circuit Breakers



CIRCUIT BREAKERS FOR PLANES, TANKS AND TRUCKS

Klixon Circuit Breakers, already approved for use in military aircraft, are being installed in not only planes but in tanks and trucks as well. Millions of these breakers are now protecting electric circuits from overloads in mobile or flying equipment

The Spencer snap-acting thermostatic disc—the control element of Klixon Motor Protectors, Transformer Protectors and many other Klixon Thermostat controls—has now taken to the air. Klixon Circuit Breakers—also operated by Spencer snap-acting discs—are going into planes by the thousands. And the reason? Simply this—Klixon Circuit Breakers are permanent protective devices. If a circuit is overloaded these breakers will open the circuit until overload conditions are removed, at which time the circuit can be reestablished by either pushing a button or switch on the breaker. Frequent replacements are unnecessary. Protection is assured. Trouble from temporary shorts is eliminated. Send for complete information.

KLIXON

TRADE MARK REG U.S. PAT. OFF

Spencer Thermostat Co., 901 Forest St., Attleboro, Mass.

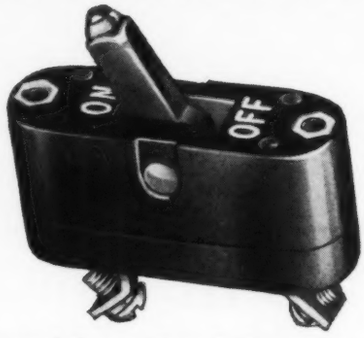
MANUFACTURERS OF THERMOSTATS AND TEMPERATURE CONTROLS FOR AIRCRAFT CABINS, RADIOS, ENGINES AND INSTRUMENTS

Klixon NAF-1131 Circuit Breaker.

Approved for military aircraft use. Weighs only 1¼ ounces. Ratings from 5-40 amps in steps of 5.

Klixon PLM-1½" Circuit Breaker.

Used for higher ratings than the NAF-1131. Compact and light in weight. Ratings range from 35 amperes up. Comes with or without luminous tip on reset button.

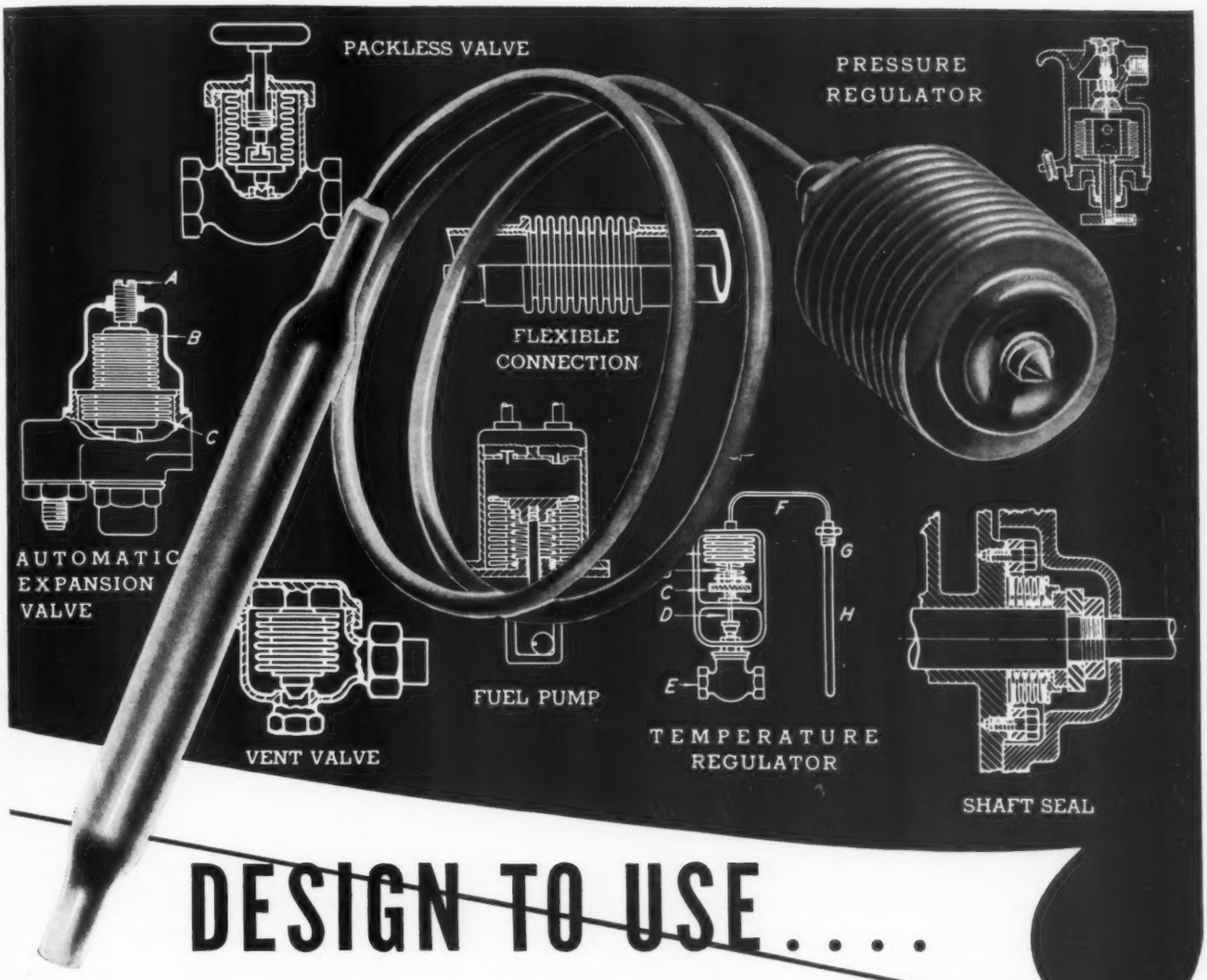


Klixon Switch-Type Circuit Breaker—Type C-6363.

Small, compact, and light in weight, this breaker is interchangeable with respect to mounting dimensions with standard aircraft toggle-switch. Ratings from 5-30 amps in steps of 5. Comes with or without luminous tip.

Klixon Switch-Type Circuit Breaker—Type D-6364.

It is light for its size. Being twice the width of the C-6363 it can be mounted in same space as two C-6363's. Ratings range from 35 amps up. Comes with or without luminous tip.



DESIGN TO USE....

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New products created, old products improved . . . designers in practically every field use Sylphon Bellows to advantage.

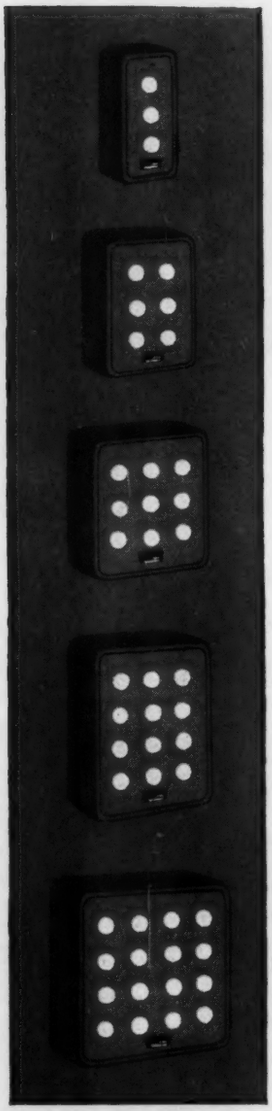
In Sylphon Thermostat Assemblies, for instance, this amazing metal diaphragm helps solve the problems of temperature control in refrigeration, heating, air conditioning and industrial processing.

As highly efficient diaphragms used to convert pressure effects into controlled movement in instruments, appliances and machines of various types . . . as flexible seals, expansion chambers, rotating shaft seals, packless glands and for endless similar purposes, the Sylphon Seamless Metal Bellows is constantly replacing less durable, less dependable materials in the products of leading manufacturers.

Sylphon Bellows were pioneered 40 years ago by The Fulton Sylphon Co. Tried and proved, many millions of units are now in service. Quite possibly you have a problem which finds its right answer in Sylphon Bellows—the modern "Miracle in Metal." Write today for Bulletin AP-535

THE FULTON SYLPHON CO.
KNOXVILLE, TENNESSEE
Representatives in All Principal Cities in U. S. A. and in Montreal, Canada and London, England

Organist



EACH HAS Finger-Tip CONTROL

Organ melodies are a blend of many separate notes struck by the musician's fingers on the organ keyboard — his control station

A multi-circuit push button station is the machine tool operator's "keyboard." It provides finger-tip control of the automatic panel which governs the sequence and timing of all operations required to create thousands of identical parts from raw metal stock.

Square D's new Class 9001, Type M series of push button stations and enclosures has been designed for more flexibility, convenience and safety in transmitting the operator's finger-tip messages to the motor control panel.

Square D offers enclosures for 3, 6, 9, 12, and 16 push button, selector switch or pilot light control units. Each may be furnished as an assembled station; or as an enclosure only, in which the machine tool manufacturer can fit units from stock to fill his immediate needs. Knockout closers are provided for unused openings in the cover plate.

Each enclosure consists of a cast iron case, gasket and steel cover plate. The case may be drilled and tapped for conduit entrance in five convenient locations.

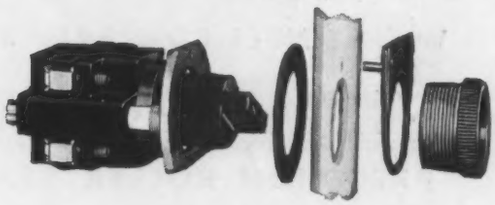
The Type M push button series supplements a wide assortment of other control stations, limit switches and accessories in the Square D line. All have been developed to make practical the complex metal working operations expected from modern machine tools.

WRITE FOR BULLETIN 9001-M

SQUARE D COMPANY

OR MACHINE TOOL OPERATOR

Drip-tight push button, selector switch or pilot light control units can be assembled in any desired combination on the cover plate. The assembly method is illustrated below in connection with a type MO selector switch.

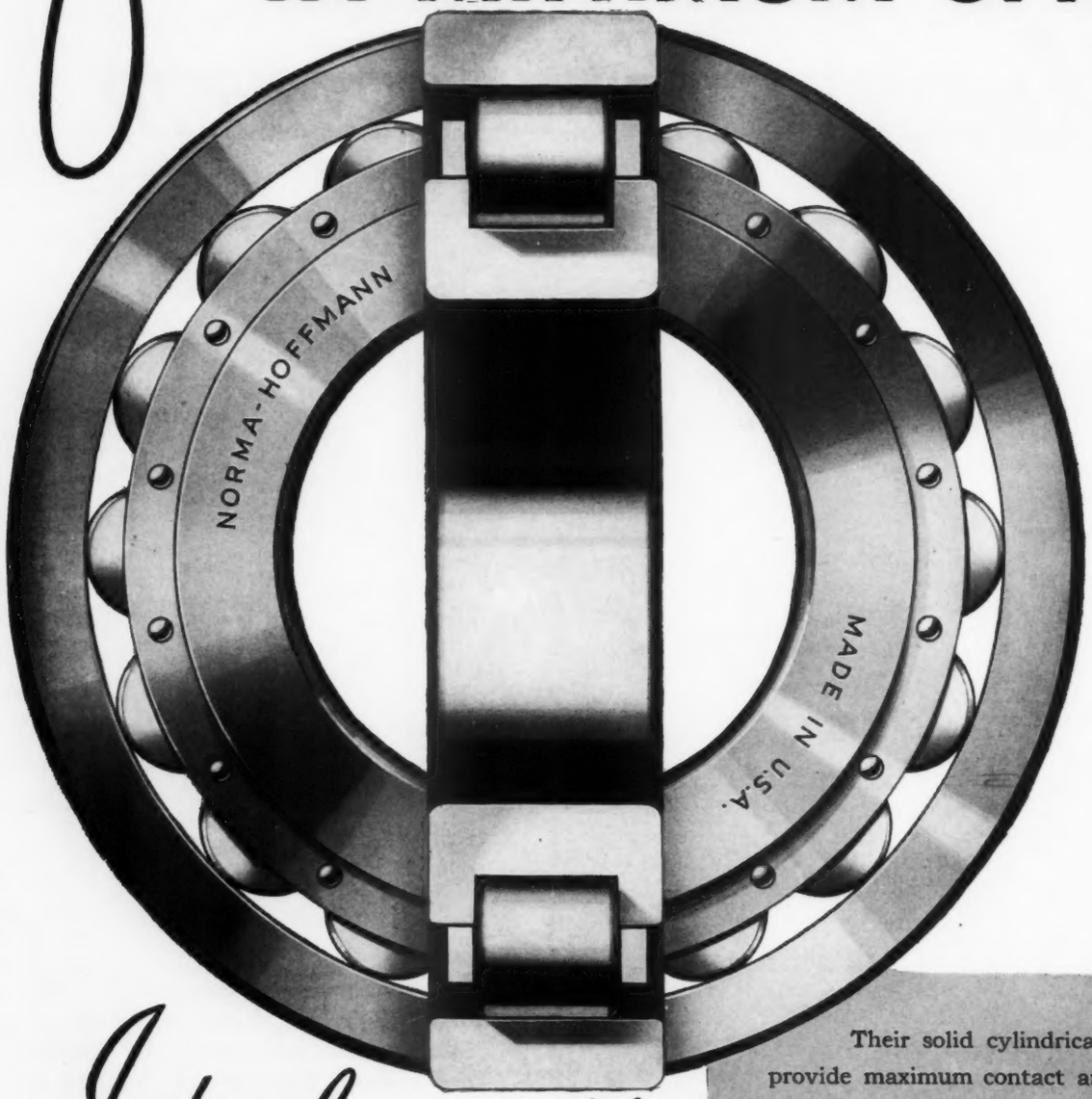


CALL IN A SQUARE D MAN

DETROIT - MILWAUKEE - LOS ANGELES

KOLLSMAN INSTRUMENT DIVISION, ELMHURST, NEW YORK • IN CANADA: SQUARE D COMPANY CANADA LIMITED, TORONTO, ONTARIO

for MAXIMUM CAPACITY IN MINIMUM SPACE



Interchangeable

WITH SINGLE-ROW BALL BEARINGS

NORMA-HOFFMANN

PRECISION ROLLER BEARINGS

NORMA-HOFFMANN BEARINGS CORP'N.,

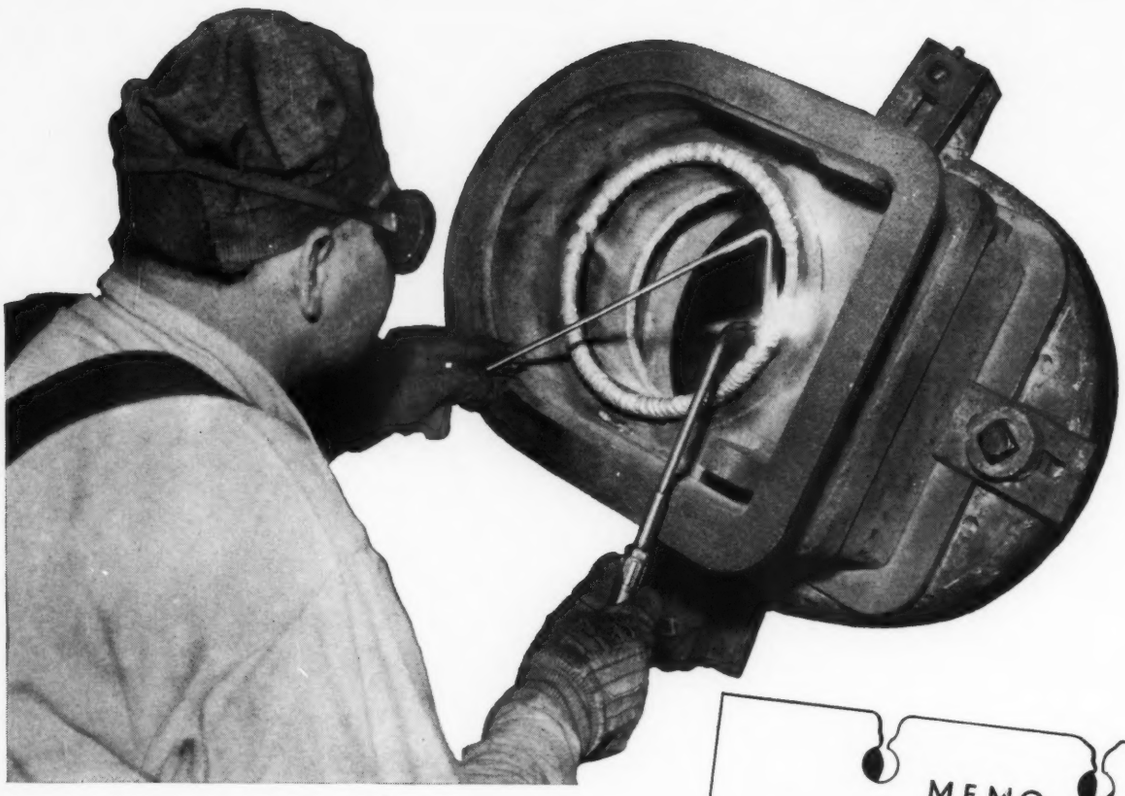
STAMFORD, CONN., U. S. A. • *Founded in 1911.*

Write for the Catalog. Let our engineers work with you.

Their solid cylindrical rollers provide maximum contact area, giving larger load and shock-absorbing capacity than any other single-row bearing of like dimensions. Thus, when NORMA-HOFFMANN PRECISION ROLLER BEARINGS are used in place of ball bearings, a greater factor of safety is provided, together with added life, particularly under vibration and overload. PRECISION qualities in workmanship and materials adapt them alike for both low and high speeds.

more gearhead motors in use today carry the
MASTER name than all other makes COMBINED
MASTER
THE MASTER ELECTRIC COMPANY • DAYTON, OHIO

WELDED DESIGN



Bronze inserts were formerly installed in marine valves of this type to insure long trouble-free service. Now a faster, simpler, less costly method does the job equally as well, if not better. Utilizing the Airco oxyacetylene flame and bronze welding rods, a "sure sealing" bronze seat is deposited on the valve. Welding eliminates a step in manufacture, saves time, conserves a valuable defense metal.

Simplified product design is often achieved by welding. With this in mind Air Reduction makes available its broad experience to assist its customers wherever possible, both on the drafting board and the production line. Full details on request.

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Conserved Material ✓

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Anything and Everything for **GAS WELDING or CUTTING and ARC WELDING**

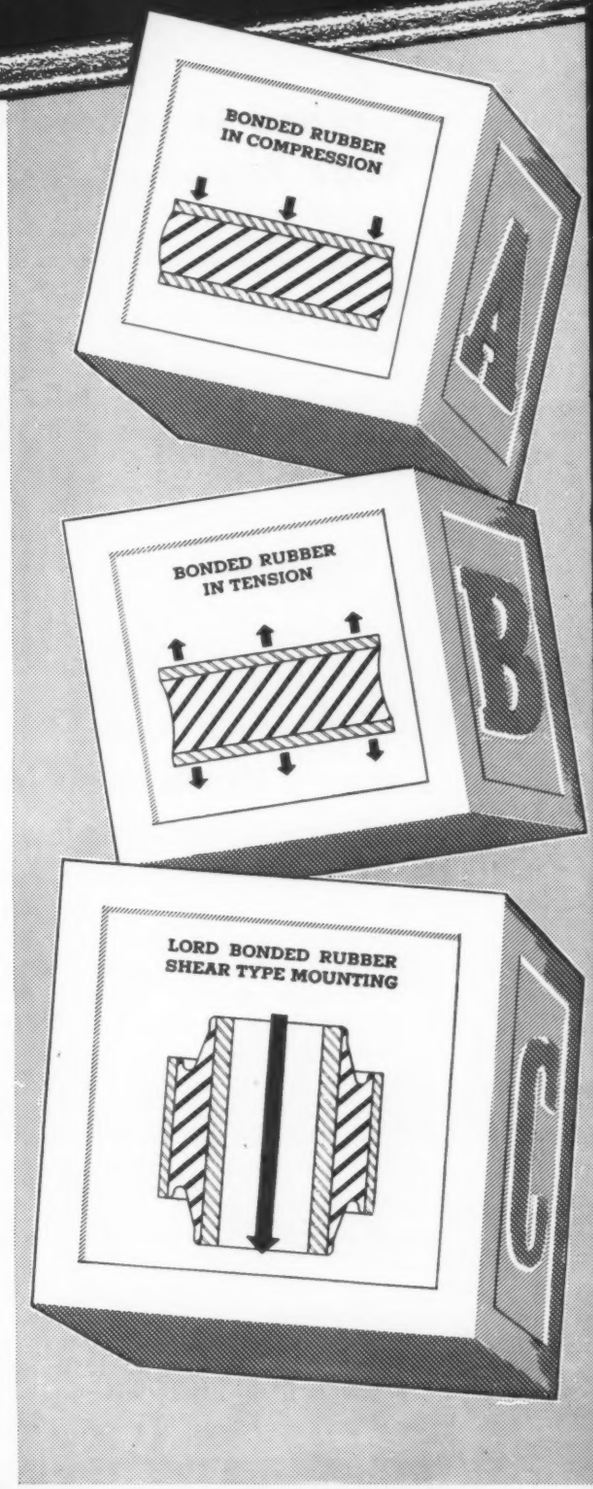
the ABC's of vibration control

A primary law of vibration control tells us that in any flexible mounting system, for a known load and disturbing frequency, the isolating efficiency of the mounting increases as the deflection of the mounting increases. The efficiency of bonded rubber mountings for supporting mechanical equipment depends largely on this condition. One of the earliest forms of rubber mounts is the simple compression pad as indicated in Block A. As rubber is an incompressible material, provision must be made for bulge or flow of the rubber as the mounting deflects. In actual practice, compression type mountings are unstable as they are soft in all directions normal to the vibratory thrusts.

Block B shows a mounting with the load applied so as to produce tensile stress in the rubber. A mounting of this type is somewhat softer than rubber in compression, but has the same lack of stability in directions perpendicular to the vibratory thrusts. When a mounting is loaded in tension, the rubber stretches, reducing the cross sectional area. In this condition, rubber is extremely sensitive to injury and any cut or tear will cause rupture and quick failure.

Rubber stressed in shear under load, which is the operating principle of all Lord Mountings, has proved to be the most efficient design for obtaining adequate deflection under load without sacrificing other desirable characteristics. As shown in Block C, mountings operating in shear do not require a large volume of rubber and are, therefore, stable in all directions normal to the vibratory thrusts. This cross-section shows a typical Lord Tube Form Mounting, which is made in various sizes for supporting loads from a few pounds to 1500 pounds each and in special sizes for any higher load rating. For supporting lighter loads, from a few ounces up to 300 pounds each, Lord Plate Form Mountings are made in numerous sizes.

For a full description of standard Lord Shear Type Mountings and an engineering discussion of vibration control, write for a copy of Lord Bulletin 104.



LORD MANUFACTURING COMPANY . . . ERIE, PA.

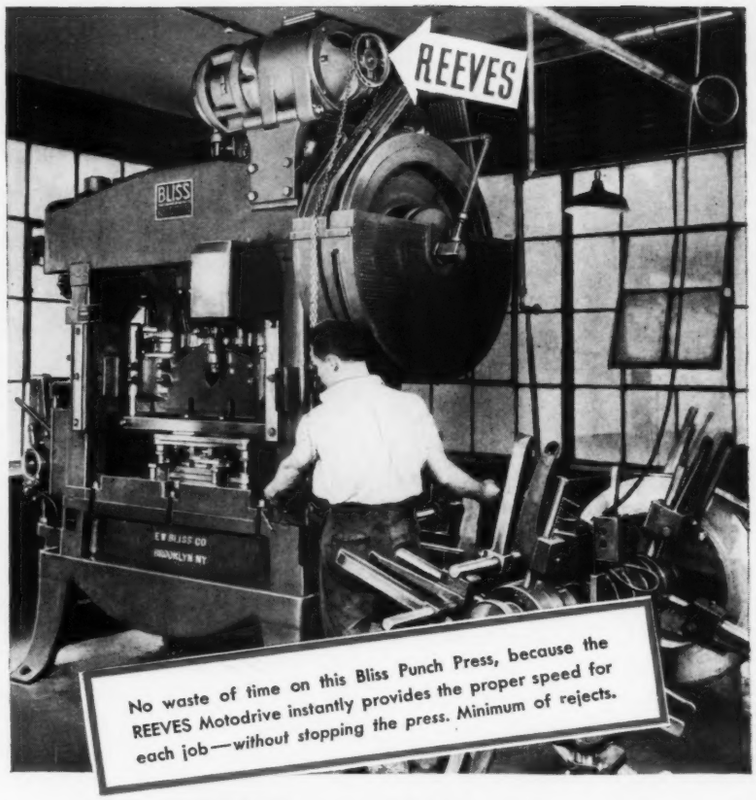
245 E. OLIVE AVE., BURBANK, CAL. 280 MADISON AVE., NEW YORK 844 N. RUSH ST., CHICAGO

IT TAKES RUBBER IN SHEAR TO ABSORB VIBRATION

Yesterday

When Rigid Economy Was Paramount . . .

When competition was at its keenest and getting costs down and profits up was the order of the day in every plant, REEVES Variable Speed Control became firmly established in industrial production. Then, as now, REEVES Speed Control made it possible to improve both the quality and quantity of output and to save costly man-hours of labor by enabling the operator to run his machine at *exactly the right speeds* for best results on every job.

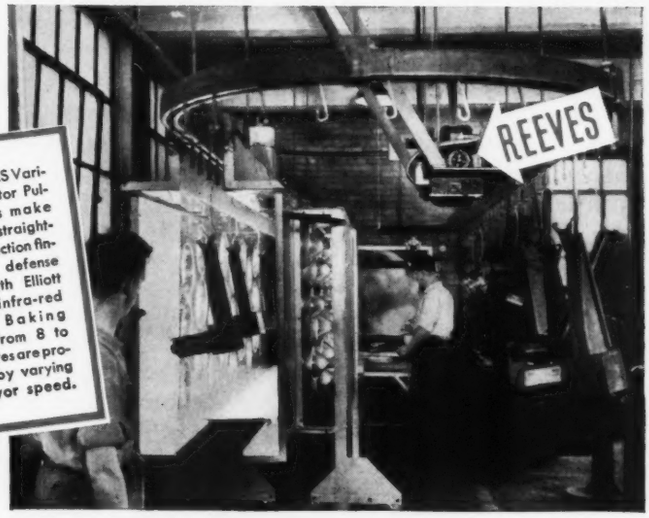


No waste of time on this Bliss Punch Press, because the REEVES Motodrive instantly provides the proper speed for each job—without stopping the press. Minimum of rejects.

Today

When Production Must Hit a New Peak . . .

Today there is no time to waste with inefficient methods, with machines operating too fast or too slow for best results. Every man-hour of labor must be made to count. Every yard, pound or gallon of precious materials must be conserved. Production must hit a new peak, but with no sacrifice of quality. REEVES Drives, which provide complete speed flexibility, are a basic factor in accomplishing these objectives.

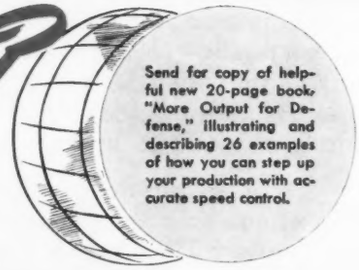


Here REEVES Vari-Speed Motor Pulley helps make possible straight-line production finishing of defense parts with Elliott Electric infra-red oven. Baking cycles from 8 to 18 minutes are provided by varying conveyor speed.

-and Tomorrow?

Tomorrow your machines may be called upon to handle entirely different materials, produced under entirely different conditions. *Applied now,* REEVES Speed Control will pay dividends in increased machine efficiency, *after the war* as well as in the present emergency. Let our engineering department help you.

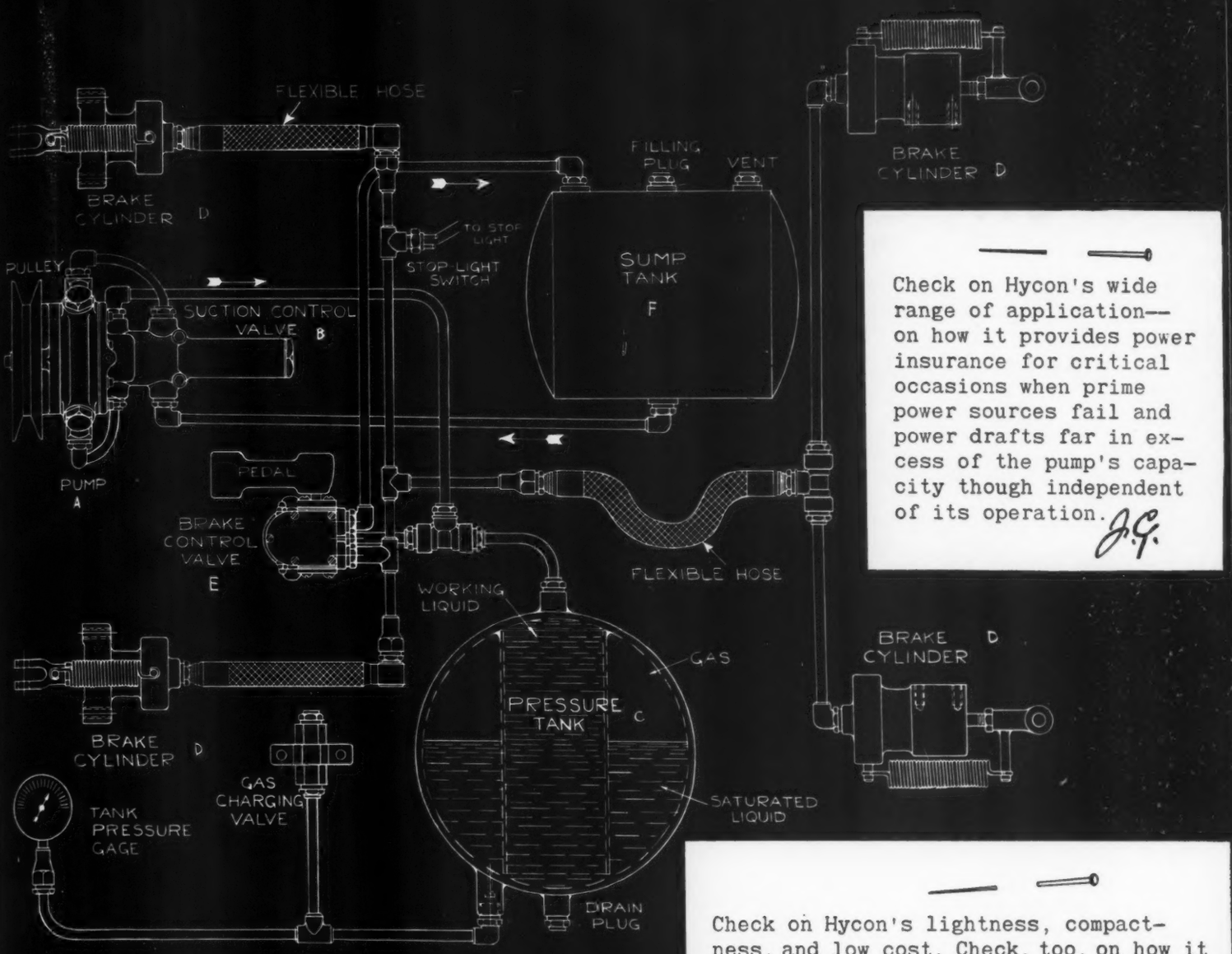
REEVES PULLEY COMPANY • *Dept. K* • COLUMBUS, INDIANA



Send for copy of helpful new 20-page book, "More Output for Defense," illustrating and describing 26 examples of how you can step up your production with accurate speed control.

Minimum Waste - Maximum Production

REEVES Speed Control



Check on Hycon's wide range of application—on how it provides power insurance for critical occasions when prime power sources fail and power drafts far in excess of the pump's capacity though independent of its operation.

J.G.

Check on Hycon's lightness, compactness, and low cost. Check, too, on how it saves power by eliminating constant pumping on intermittent operations and operates under all ordinary temperature conditions without adjustment.

J.G.

HOW THE HYCON SYSTEM ACTUATES AND CONTROLS SPEED AND PRESSURE IN STRAIGHT LINE MOTION MECHANISMS WITH STORED HYDRAULIC PRESSURES UP TO 3000 LB PER SQ IN.

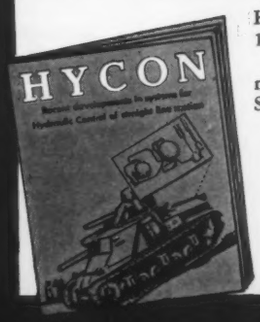
Typical installation with Hycon pump and pressure tank actuating 4 work cylinders

The diagram shows a typical assembly of HYCON equipment. The work cylinders (D) may serve any desired function such as the movement of a brake, clutch lever, door, electric circuit breaker. To these, hydraulic pressure is applied in any amount up to the designated limit by the control valve (E). The energy for actuating the work cylinders is primarily derived from the pressure tank (C) and this in turn is charged by the pump (A). The delivery from the pump is governed by the suction control valve (B). The work cylinders on the return stroke discharge into the sump tank (F) from which the fluid is pumped into the pressure tank and/or the work line.

HYDRAULIC CONTROLS, INC. *(Division of The New York Air Brake Company)*
122 South Michigan Avenue, Chicago, Ill.

GET THE FACTS ON HYCON

...u are facing the problem of designing a control or control actuating system for any mechanism employing straight line motion, information on Hycon is important to you. With it you can achieve greater flexibility of design, accuracy of control, and, probably, increased machine capacity at lower cost. Details concerning the system and its working parts are covered in the recently prepared booklet, "Recent Developments in Systems for Hydraulic Control of Straight Line Motion." Please let us know where to send your copy.



Hydraulic Controls, Inc., Dept. 107
122 South Michigan Avenue, Chicago, Ill.

Please send me my copy of "Recent Developments in Systems for Hydraulic Control of Straight Line Motion" to:

Name.....

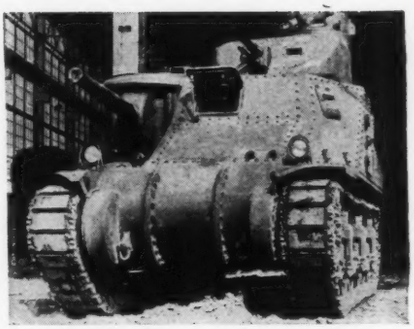
Company.....

Street Address.....

City.....*State*.....

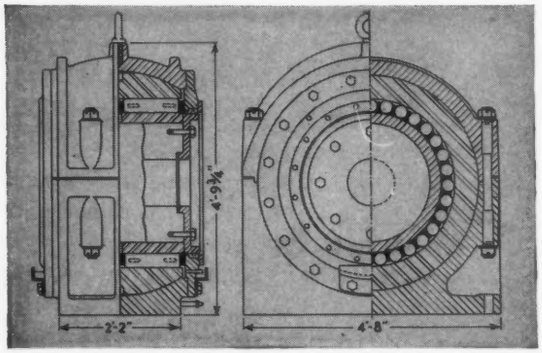
IN THE NEWS

WITH BANTAM BEARINGS

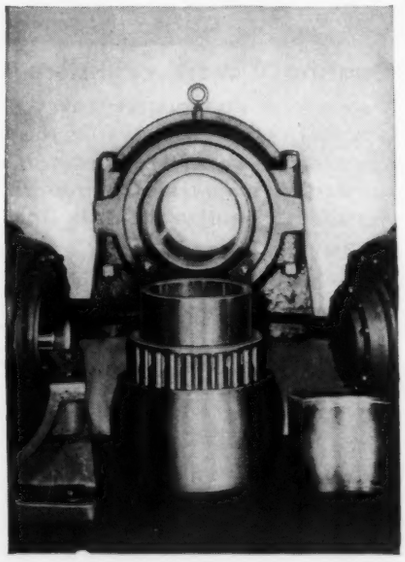


"BIG BRUISER" is this M-3 28-ton tank shown leaving the assembly line of the Chrysler Tank Arsenal. In the transmission, Bantam's Quill Roller Bearings aid in passing the tremendous driving power from motor to tractor treads. Maintaining a prompt, efficient flow of bearings of all types to the assembly lines of industry is Bantam's first job in helping meet the demands of the rapidly increasing production of defense material.

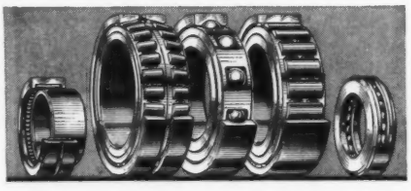
ENGINEERING ADVANCEMENT for new Chicago project is the use of radial roller bearings in the bascule type bridge now under construction for North State Street. The bridge, a perspective study of which is shown above, will rank among the largest of its kind in the world, with a width of 108 feet and a clear span of 210 feet. Two 36-foot roadways will be provided. Shown at left is cross-section of one of the large (47½" O.D.) Self-Aligning Roller Bearings, designed and built by Bantam, which will support two sets of three trunnions which in turn will carry the two movable leaves weighing 8,500,000 lbs. each. Self-aligning features, provided by spherical outer races resting in spherical housing seats, will compensate for any possible load deflections that may take place—another example of Bantam's engineering skill in designing anti-friction bearings for new and unusual requirements. Furthermore...



THE MANY ADVANTAGES of Bantam's compact, high capacity Quill Bearing are making it increasingly in demand for defense needs, where dependability and long-time maintenance-free service are primary considerations. A self-retained unit, easily installed and lubricated, it is ideally adapted to production line assembly methods. And its small size permits savings in materials of surrounding parts. For details on this unusual bearing, write for Bulletin R-104.



Substantial savings in size of electrical equipment and in power operating costs will be made through the use of Bantam Radial Roller Bearings. Only four 75 HP series motors will be required to operate the bridge, while the lower servicing and maintenance requirements of these bearings will bring additional savings. Bantam Bearings, such as those shown at left, have already been applied with gratifying results in other types of bridges. Breakaway and running loads have been reduced, and spans are moved with greater ease.



EVERY MAJOR TYPE OF ANTI-FRICTION BEARING is included in Bantam's line—straight roller, tapered roller, needle, and ball. If you have a difficult bearing problem, TURN TO BANTAM.

BANTAM BEARINGS
STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL
BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

— and the answer is under his thumb!

Silver — the metal in the pencil — may be the best metal to meet the requirements. What other metal offers such industrially valuable qualities as SILVER?

It is one of the most ductile and workable metals known and combines readily with other metals to make useful alloys that have unusual properties. Silver is practically indestructible in its immunity to many kinds of corrosion and it is a superior conductor of electricity and heat. Silver is the whitest of metals and has high reflectivity. It also has excellent germicidal qualities and the salts of silver are photo-sensitive.

Industry is becoming increasingly aware of SILVER, learning that its cost is often unimportant compared to its advantages — almost negligible in many cases, due to the small quantity needed.

Much vital data concerning Silver and its industrial uses is on record and readily available through the Service described at the left. If you have a specific metal problem, find out whether Silver can help to solve it. We invite you to write us.

SILVER DATA and RESEARCH . . .

The American Silver Producers' Research Project has for some years carried on a comprehensive research program covering silver and silver alloys for general and specific industrial uses. This research continues today under direction of Handy & Harman who specialize in supplying silver to the arts and industries.

A great deal of valuable data has been accumulated. These data are available to anyone interested in silver and its alloys for industrial application.

The full cooperation and research facilities of the Project are also offered for working out solutions to specific problems.

AMERICAN SILVER PRODUCERS' RESEARCH PROJECT
Under Direction of Handy & Harman
82 Fulton Street New York, N. Y.

f it's a metal problem, think of SILVER!

CUSHIONED ROLLER ASSURES LONGER WEAR!

When the sprocket teeth mesh with Silverlink roller chain, the unique curled roller acts as a shock-absorbing spring which resists hard blows—reduces wear and repairs!

● When you look at a section of Link-Belt roller chain, you know it has *everything!* Its brilliant beauty is in keeping with its high quality and precision design. Its great strength, and durability assure dependable, low-cost service. Send for Engineering Data Book No. 1757.

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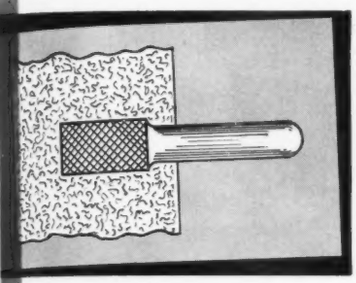
Leading Manufacturer of Mechanical Transmission Equipment—Silent and Roller Chains . . Speed Reducers . . Speed Variators . . Roller, Ball and Babbitted Bearings . . Collars . . Couplings . . Base Plates . . Take-Ups . . Clutches . . Gears . . Sprockets . . Hangers . . Shafting . . Pulleys, etc.

LINK-BELT *Silverlink* ROLLER CHAIN

Designing Molded Plastics Parts: *INSERTS*

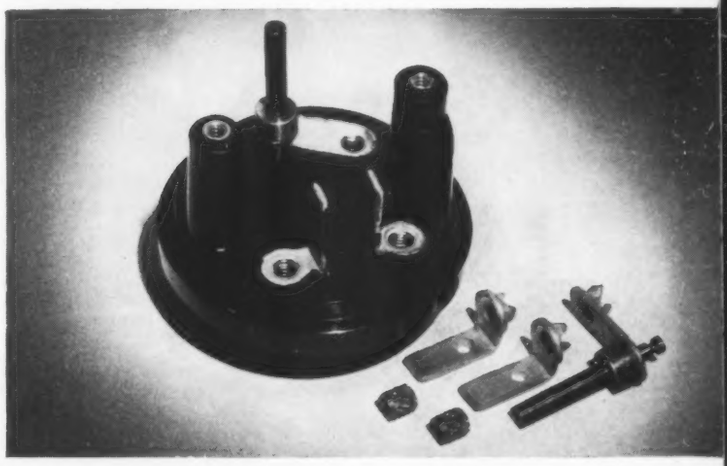
from the engineering files of One Plastics Avenue

To incorporate inserts in molded plastics parts the following general factors should be considered: (1) Avoid use of delicate inserts for compression type molds. (2) Use simple shaped inserts, preferably round, for easy cleaning. (3) Minimum amount of plastics around insert: 3/32 in. for ¼ in. insert; ⅛ in. for ½ in. insert; ¼ in. for inserts over ½ in. (4) Keep inserts from corners and edges. (5) Placement of inserts should be at right angles to parting lines. (6) Knurl, punch or groove inserts for good anchorage. (7) Where metal inserts are used as electrical contacts, provide proper air gaps at point of arcing to avoid burning or carbonization of plastics. (8) If possible, avoid using inserts for injection molded thermoplastics.



◄ ROD AND WIRE INSERTS

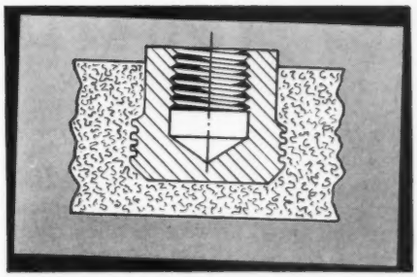
The best general length to diameter ratio is 2 to 1 wherever practicable. For compression molded parts the maximum ratio of length to diameter of rigid inserts should be 4 to 1 if one end is supported, 8 to 1 if both ends are supported.

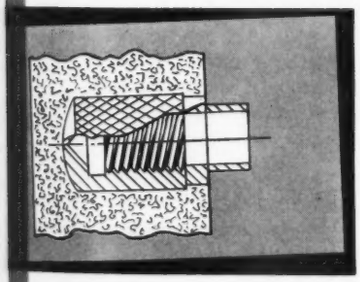


TYPICAL APPLICATION Typical of molded parts incorporating inserts is this electrical switch section which has five separate inserts including each of the major types—rod, threaded and stamped.

THREADED INSERTS ►

The preferred ratio of length to diameter for all threaded inserts is 2 to 1. Always use a coarse knurl on rag compounds, and as coarse as possible for other compounds. Where heavy loads are encountered design insert to carry the load; do not put load on plastic part. Female inserts are generally stamped after molding. Length of thread should be kept to minimum and projecting end of insert should be smooth, round and free from knurl.



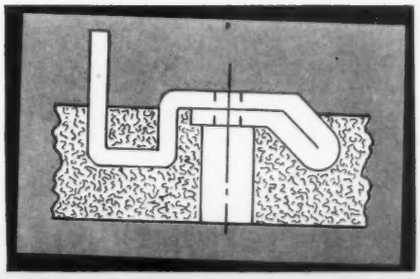


◄ SPUN-OVER INSERTS

For anchorage, dimensions, materials, same rules apply as to threaded inserts. This is a good method of assembling contact strips, washers, etc., on the molded part.

STAMPED OR PUNCHED ► INSERTS

Avoid delicate or unsupported projections in compound. For rag or fabric compound use rigid inserts whenever possible. Good anchorage important. Laminated metal inserts may be molded.



ADDITIONAL FACTS General Electric has 14 standard female inserts. Inserts of Mycalex, porcelain, woven wire mesh, laminated phenolic material, woven glass, etc., can be molded in plastics parts. Because of current shortages metal inserts should be used only when essential to part. G.E.'s consulting engineering service will advise you on best methods of design.

ONE PLASTICS AVENUE at Pittsfield, Massachusetts, is the headquarters for five plants of the Plastics Department of General Electric Company. It signifies the location of complete plastics facilities for development, material manufacture, designing, engineering, moldmaking, molding and laminating.

REPRINTS of this advertisement may be obtained by writing Section C-1, General Electric Plastics Department, Pittsfield, Mass.

PLASTICS DEPARTMENT
GENERAL ELECTRIC

PROVED IN THE FIELD

"Jeeps" have frames of

DUCTILITY

ITS INHERENTLY FINER GRAIN MAKES ALL THE DIFFERENCE

STRENGTH

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High Tensile

(9115)

The proof of the pudding is in the eating. Likewise the proof of the "Jeep" to stand the gaff, was in the field. It came through with flying colors—it stood the test, over rough terrain, under all types of weather conditions.

The "Jeeps" have frames made of N-A-X HIGH TENSILE. And it wasn't just by chance that this superior low alloy steel was used. Long before the necessity for this important unit of the armed service was urgent, N-A-X HIGH TENSILE had proved highly successful in hundreds of exacting applications, in many of which other comparable steels had failed.

With such a record behind it, it was natural for manufacturers and fabricators to use N-A-X HIGH TENSILE for frames of the "jeeps" and also for a wide variety of other defense applications. For this superior steel possesses properties which make it ideal for equipment so vital to the defense of America.

N-A-X HIGH TENSILE can be fabricated by all standard shop methods—it goes through each step in cold or hot forming and welding smoothly, quickly, economically. And because of its outstanding ductility, finished equipment has greater resistance to the destructive forces of stresses, shocks, impact and fatigue, over rough terrain, in both extremely hot and sub-zero weather.

We shall be glad to furnish additional information. A Great Lakes engineer will call at your convenience, show you how hundreds of others have used this remarkable low allow steel to advantage. Wire, telephone or write today for a Great Lakes engineer. No obligation.

Send for Booklet on our 9100 Series—the Versatile Alloy Steel

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Hot Rolled Strip (down to 1 inch wide) . . . Hot Rolled Strip Sheets (up to 91 inches wide) . . . Spring Steel (carbon and alloy) . . . Merchant Bars . . . Forging Bars . . . Automobile Bumper Sections . . . Bar Mill Sections . . . N-A-X HIGH TENSILE Bars, Shapes, Sheets, Billets . . . Sheet Bars . . . Hot and Cold Rolled Sheets . . . Michigan Metal for Vitreous Enameling . . . Deep Drawing Quality (in all grades, widths up to 91 ins.) . . . Stran-Steel Metal Framing for Residential and Commercial Construction.

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STRENGTH PLUS...

The plus properties of these 8 INCO Nickel Alloys meet a wide variety of fabrication and service requirements...

Strength combined with corrosion resistance, as you know, have long been associated with Monel. But sometimes you need extra hardness, heat resistance, resilience, or some additional property. These and other *plus* characteristics are offered by other INCO Nickel Alloys. Find out more about this useful family of metals. Write for the new booklet, "Individualized INCO Nickel Alloys."

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street — New York, N. Y.

plus **CORROSION RESISTANCE** . . . together with strength, hardness, toughness —	**MONEL**
plus **EXTRA HARDNESS** . . . comparable to heat-treated alloy steel; heat-treatable, non-magnetic —	**"K" MONEL**
plus **HEAT RESISTANCE** . . . with retention of high degree of strength. Resists oxidation, high corrosion resistance —	**INCONEL**
plus **MACHINABILITY and EXTRA HARDNESS** . . . free cutting, heat-treatable, non-magnetic —	**"KR" MONEL**
plus **RESILIENCE** . . . heat-treatable, for exceptional spring properties, magnetic, good electrical conductivity —	**"Z" NICKEL**
plus **MACHINABILITY** . . . for high speed production in automatic screw machines —	**"R" MONEL**
plus **HARDNESS in CASTINGS** . . . anti-seizing and non-galling —	**"S" MONEL**
plus **NON-CONTAMINATION** . . . protects product purity; offers good electrical conductivity —	**NICKEL**

★ FIRST THINGS FIRST ★

With the Nation at war, supplies of Monel, Nickel and Nickel Alloys are needed for our armed forces. Although all efforts must now be aimed toward victory, The International Nickel Company will continue to report developments for the information of metal users who are concerned with the war efforts of today and the peace-time progress of the future.

SOME TYPICAL MECHANICAL PROPERTIES

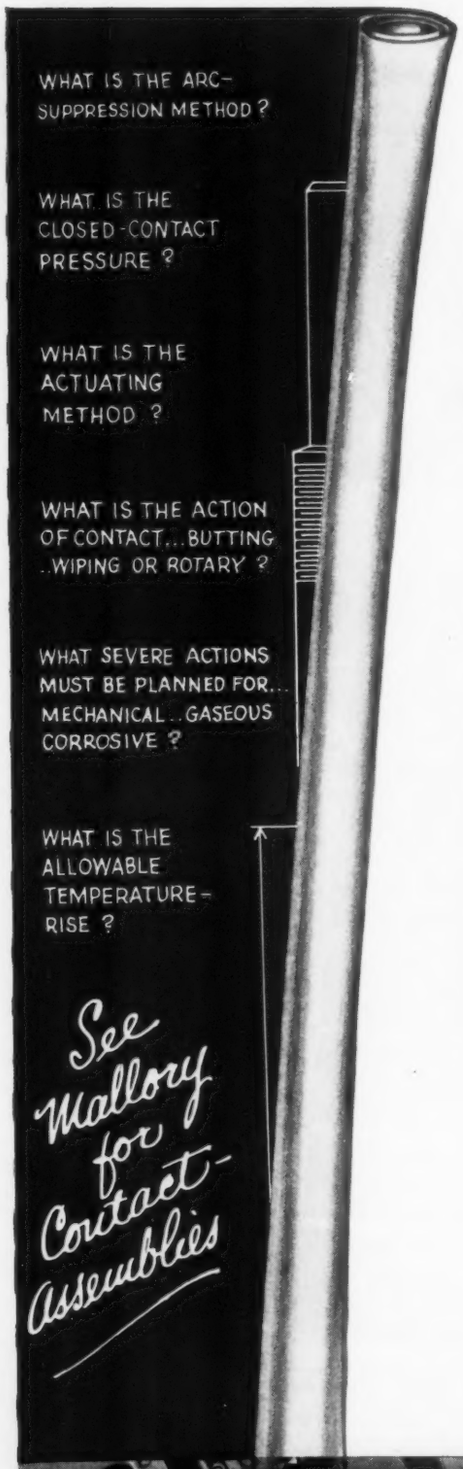
INCO ALLOY	*CONDITION*	*Tensile Strength 1000 psi.*	*Yield Strength 0.2% Offset 1000 psi.*	*Elongation in 2 in. per cent*	*Hardness Brinell 3000 kg.*	*Toughness Standard Izod-ft.-lbs.*
MONEL.....	Cold-drawn, as drawn.....	85-125	60-120	35-15	160-250	115-75
"K" MONEL.....	Cold-drawn, heat-treated....	140-170	100-130	30-15	260-320	26*
INCONEL.....	Cold-drawn, as drawn.....	95-150	70-125	30-15	180-290	100-70
"KR" MONEL..	Cold-drawn, heat-treated....	140-170	100-130	30-15	260-320	. .
"Z" NICKEL....	Cold-drawn, heat-treated....	160-190	120-150	20-7	300-380	25
"R" MONEL.....	Cold-drawn, as drawn.....	80-115	50-100	35-15	150-230	99
"S" MONEL.....	Castings as cast.....	110-145	80-115	4-1	275-350	9-3
NICKEL.....	Cold-drawn, as drawn.....	65-115	40-90	35-15	125-230	120

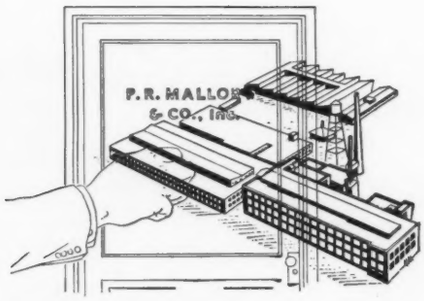
**Specimen completely fractured.*

INCO NICKEL ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • NICKEL • "Z" NICKEL

Sheet . . . Strip . . . Rod . . . Tubing . . . Wire . . . Castings


WHAT IS THE ARC-SUPPRESSION METHOD ?
WHAT IS THE CLOSED-CONTACT PRESSURE ?
WHAT IS THE ACTUATING METHOD ?
WHAT IS THE ACTION OF CONTACT...BUTTING ..WIPING OR ROTARY ?
WHAT SEVERE ACTIONS MUST BE PLANNED FOR... MECHANICAL..GASEOUS CORROSIVE ?
WHAT IS THE ALLOWABLE TEMPERATURE-RISE ?
See Mallory for Contact Assemblies



Tap Mallory Experience for the Complete Contact Assembly that "Blends with the Blueprint"

While you are seeking mechanical perfection in the design, make certain of the efficiency of the electrical contacts. Blend Mallory's contact experience with your blueprints.

Years of specialization in electrical contacts have made it apparent that often the selection of the right contact material, the proper contact design, furnish only partial answers to certain problems. Composition and design of contact members may be equally important in attaining adequate efficiency.

The result has been an added Mallory Service—the recommendation of complete contact assemblies. Through its staff of experienced metallurgists and design engineers, Mallory has found effective solutions for a host of contact problems. Mallory complete contact assemblies have given the answer time and again to greater electrical efficiency, and not infrequently, at a substantial reduction in production costs.

The Mallory representative will be glad to tell you the full story of contact assemblies.

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Complete information on every phase of electrical contact selection, design and service. You need it for your technical library. Write today. No obligation.

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ELECTRICAL CONTACTS AND CONTACT ASSEMBLIES
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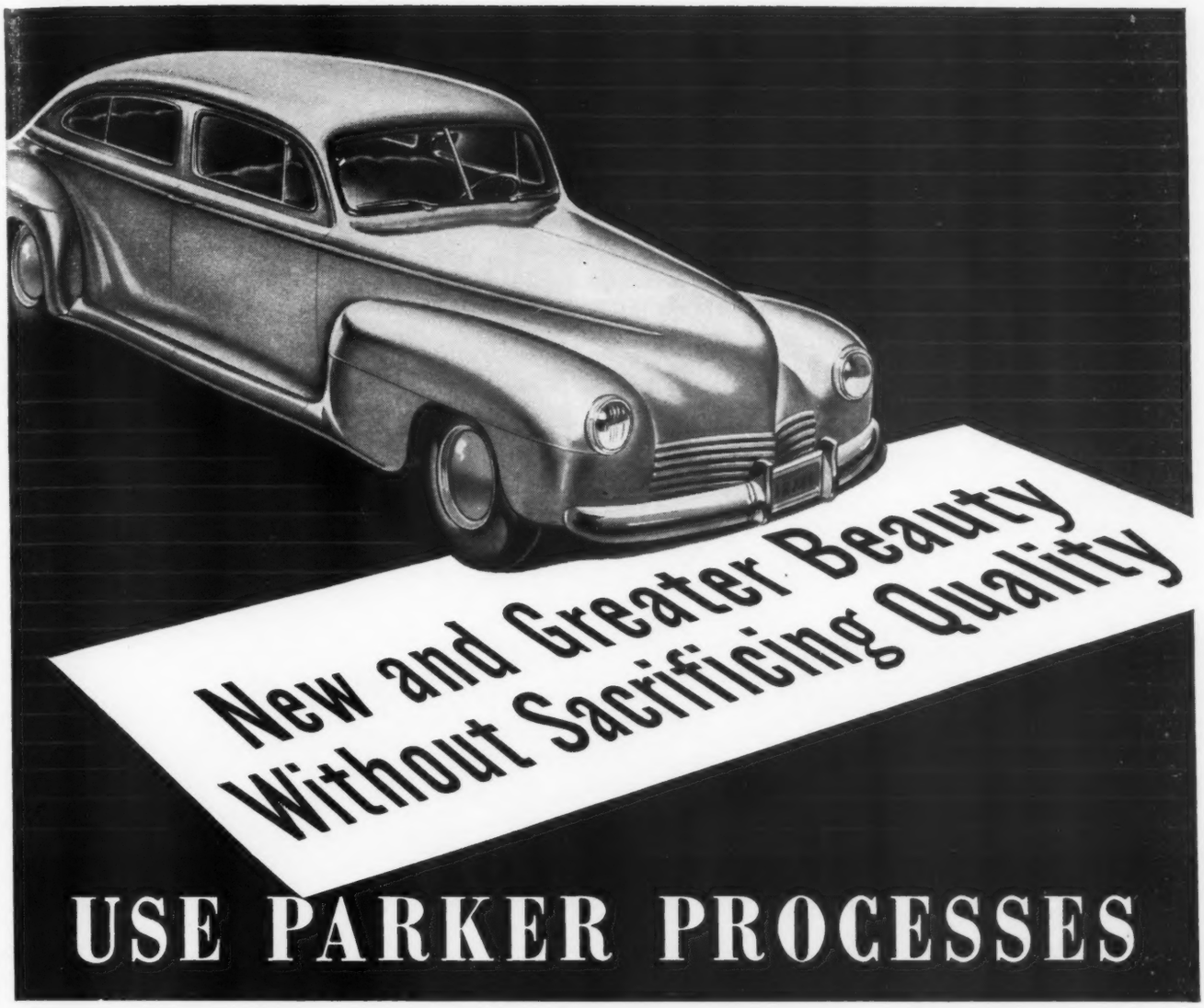

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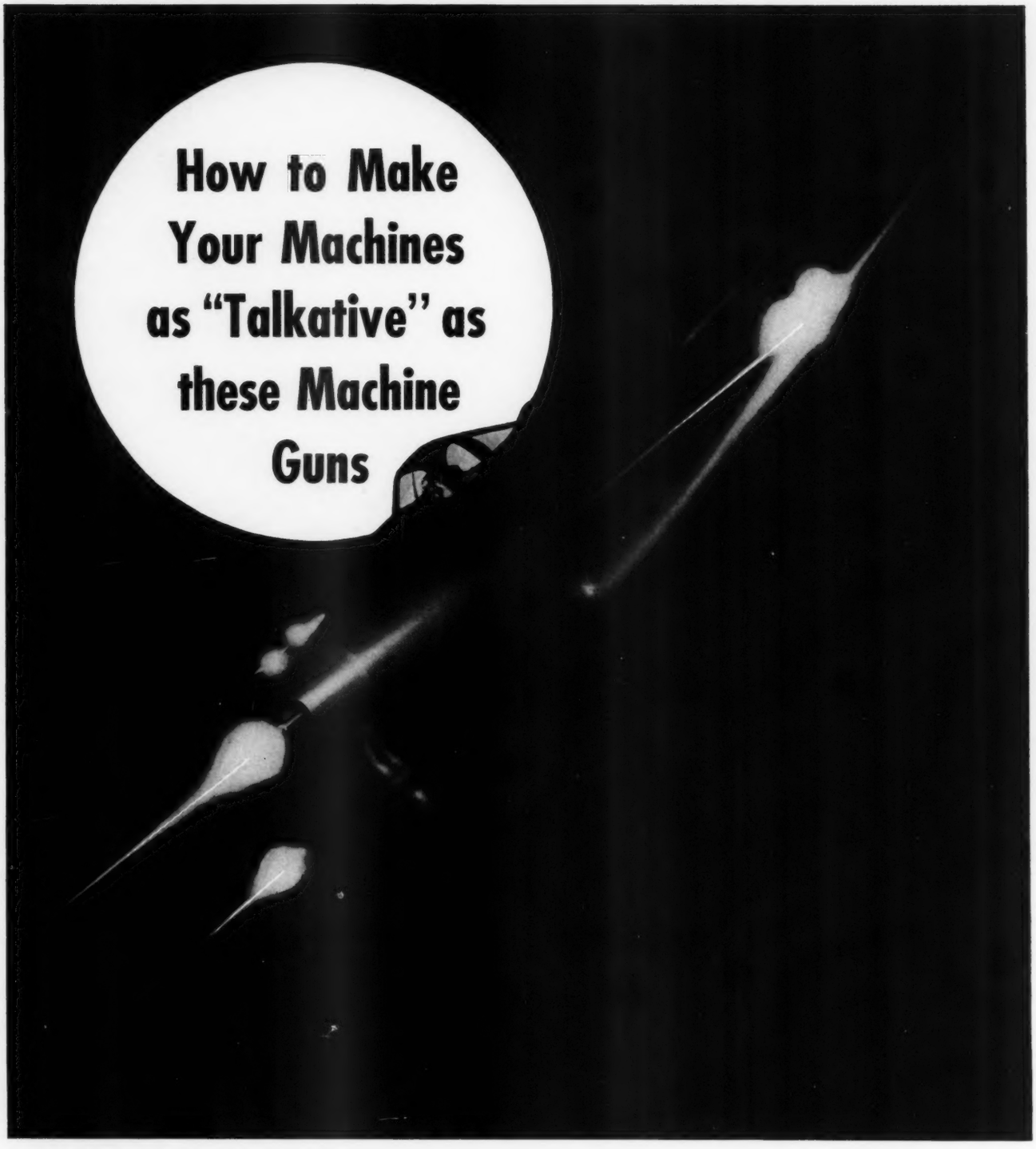

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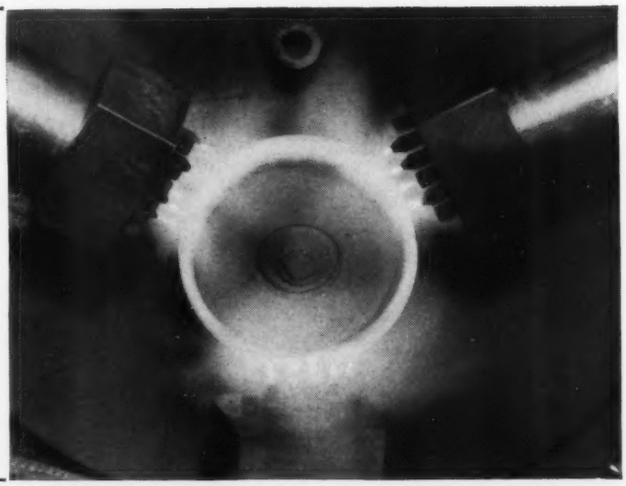
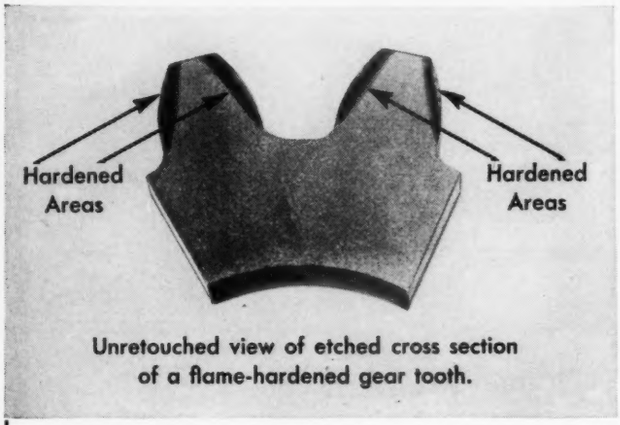
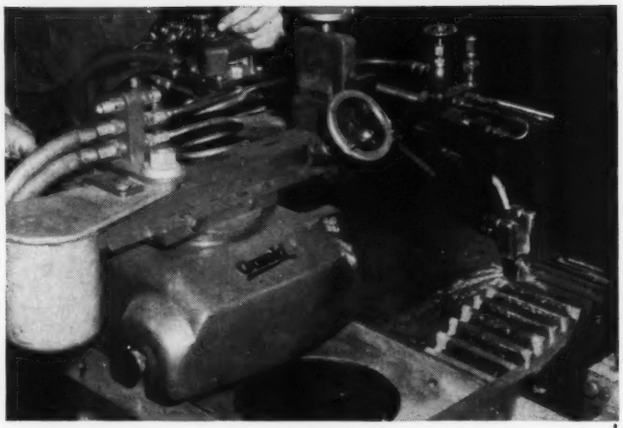
Oxy-acetylene flame-hardening imparts a hard case to wearing parts to make them last longer. This is done by heating the area to be hardened with oxy-acetylene flames, and then quenching with water or oil. Commonly used steels and high-tensile cast iron can be flame-hardened successfully. Small areas can be hardened by the "spot" method, using a hand welding blowpipe. Larger areas are usually hardened by mechanized equipment, using the "progressive" method or—as shown in the illustration at the right—the "spinning" method.





Unretouched view of etched cross section of a flame-hardened gear tooth.



2. What its advantages are

In many cases, oxy-acetylene flame-hardening is not only the best method, but the *only* practical method. Some of its advantages are:

- Parts of any size or shape can be hardened.
- There is no appreciable distortion.
- Toughness of the core is unaffected.
- Chemical composition of the metal is unchanged.
- Penetration can be closely controlled.
- The hardened area does not spall off.
- It permits use of cheaper base metals.
- Only a moderate equipment investment is required.

3. Typical parts being hardened

In the illustration above, Oxweld flame-hardening equipment is being used to impart a hard case to the teeth of a crane gear — at only the points where wear occurs. A few of the many other parts which are hardened—or fabricated—with the help of this oxy-acetylene process are:

Sprockets	Cams	Piston Rods
Dies	Crane Wheels	Pump Plungers
Sheave Wheels	Bearing Raceways	Crossheads
Shear Blades	Shafts	Saw Blades

Linde can supply the gases, the apparatus, and help in using flame-hardening. If you are interested in giving longer life to wearing parts, *talk it over with Linde!*

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You can avoid delays by incorporating the Needle Bearing in your designs *now*—and you can profit as well by its adaptability to the solution of a wide range of bearing problems. Torrington engineers will be glad to work with you in incorporating the advantages of the Needle Bearing in your product. For full details on this unusual bearing, write for Catalog No. 108.

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TORRINGTON NEEDLE BEARING

REDUCTION IN WEIGHT

and availability when needed are among the outstanding reasons for the use of Needle Bearings in many aircraft applications. A typical instance is its use on the cowl flap control rod of P-40 pursuit planes built by Curtiss-Wright Corporation.

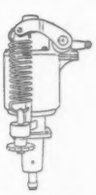
CURTISS—WRIGHT

COMPLETE RELIABILITY

is essential in such materials handling equipment as the Towmotor Lift Truck, which is subjected to severe service and heavy loads. Towmotor assures reliable bearing performance by using Needle Bearings on steering axle and hydraulic lifting cylinder crosshead.

TOWMOTOR LIFT TRUCK

HIGH CAPACITY IN SMALL SPACE



is obtained by the use of Torrington Needle Bearings on the rocker shaft of Class 2600 Governors built by The Pickering Governor Company. Compactness of the Needle Bearing contributes to simplification in product design and to accurate governor operation.

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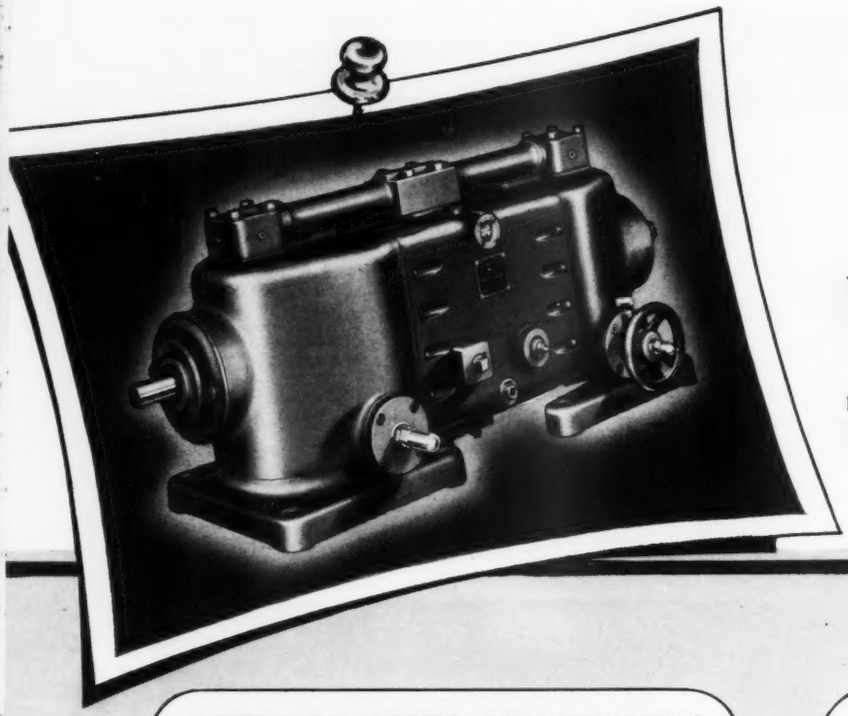

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Speed and torque control is more accurate and more flexible. Various types of manual and automatic control (hydraulic, electrical or mechanical) arrangements are available. The unit can be stalled repeatedly without damage, being protected automatically with pressure overload relief devices.

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PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

To Hasten The Day of Victory

THE WAVE OF RIGHTEOUS ANGER and indignation that swept throughout the United States on Sunday, December 7, established a united determination to crush Japan and wipe out her militaristic power. All patriotic American citizens know that this must be done and we have the fullest confidence that it will be done. But if we underestimate the power of our foe and fail to put forth at once a supreme effort, the eventual sacrifices necessary to win will be staggering. Only by immediate full action on the part of all can we hasten the day of victory.

The Japanese are a sacrificing people. They willingly endure hardship and deprivation and practice economy to a degree that is unmatched. Japanese scientists and engineers rank high. They have concentrated their efforts on the most effective and most efficient use of the limited materials they have available. One might say that in Japan they put to good use all of the 32,000 ounces in a ton of steel. In contrast, we are wasteful and extravagant.

Truly this is a war wherein the science and industry of the United States and its allies are pitted against that of the Axis gangsters. Materially we have a tremendous potential power. But the full force of that power cannot be brought into being unless we willingly work and sacrifice to excel Japan in the efficiency with which we use materials.

Many ways and means can be applied to make more with less material. In many instances, materials that are less scarce can be used. Other possibilities include simplification of the design so as to require less material, design of fewer models, more standardization and the use of reclaimed materials. The effectiveness with which methods of materials saving are applied depend largely, almost entirely, on the ingenuity of our design engineers and the vigor with which they apply their abilities. All possible speed will be necessary.

In the field of design of consumer products, many of the past standards will have to be discarded. Many products will have to be designed for a shorter life expectancy. Many "sales features," "extras" and operating conveniences will have to be done away with for the time being. Frankly, "inferior" design will have to be acceptable, by force of circumstances.

In addition to the "material economy" put into the design by the design engineer, economies will have to be made in manufacturing. Scrap reclamation and the reclamation of defectively made parts offer great possibilities. Here again the design engineer can be of great help. Fewer different metals and alloys means less work to reclaim the scrap. Also, by the shrewd design of parts that are difficult to make, the job of salvaging defective parts might be made more feasible.

This is now America's number one job, a job that is largely up to the design engineers to do. PRODUCT ENGINEERING'S contribution to this all-out effort will include data, information, suggestions and reports in directly usable form that will help to solve the engineering design problems we face and must solve to hasten the day of complete victory.

SPRING STEELS – I

Data Required for Selection

H. CARLSON
Lee Spring Company, Inc.

TO SELECT the proper spring steel for a specific application the design engineer should have a working knowledge of steel manufacture, of wire manufacture, and of the effects of alloying elements found in spring steels. He should have at his fingertips up-to-date data on compositions, tensile strengths, tolerances, costs, and applications. It is the purpose of this two-part article to present these comparisons and up-to-date data on the principal spring steels so that the product engineer can readily refer to them.

Spring steels are somewhat similar to ordinary steels except that much greater care and more operations are required to produce them and higher carbon and manganese contents are used. As a comparison of carbon content for illustrative purposes, the range used in S.A.E. 1020 machine-steel in general use for shafts, bars, rods and structural shapes, is 0.15 to 0.25 percent whereas the range for S.A.E. X1065 standard oil-tempered spring steel is 0.60 to 0.75 percent—an average of three to four times as much carbon. The effect of each alloying element is discussed in the following paragraphs.

CARBON. An increase of carbon, up to 1.20 percent, raises the tensile strength, elastic limit and hardness, but decreases the ductility, toughness and shock resistance. Closely controlled ranges are required for each type of steel.

MANGANESE. This element, within definitely prescribed limits varying with each type of steel, adds to the tensile strength and reduces the distortion and dimensional changes occurring during heat treatment.

SILICON. Most spring steels contain from 0.10 to 0.30 percent, but addi-

tions of silicon to ordinary high carbon steel in ranges from 1.80 to 2.20 percent raises the tensile strength without sacrificing ductility or toughness. The resultant alloy is called silicon-manganese steel (manganese from 0.60 to 0.90 percent) and is described more fully later in this article.

CHROMIUM. Slight additions of chromium, usually in quantities from 0.80 to 1.10 percent, increase tensile strength, hardness and toughness, reduce the necessity of having high carbon contents, increase resistance of steel to attack by acids and alkalies and increase its ability to withstand elevated temperatures. Stainless steels derive their resistance to corrosion by containing from 12.00 to 20.00 percent chromium.

VANADIUM. The addition of vanadium in small quantities from 0.15 to 0.25 percent raises the tensile strength, elastic limit and toughness and increases the ability of the alloy steel to resist impact shock and alternating stresses.

PHOSPHORUS AND SULPHUR. These are the two most undesirable elements in spring steel. They reduce the strength, ductility and shock resistance and increase the brittleness. The maximum amount of either element permissible in any spring steel is 0.055 percent; much smaller quantities are preferred. The actual amount of either one found in most compositions is less than one-half of 0.055 percent.

Specifying a spring steel with the most suitable combination of these elements for each particular spring application is of utmost importance to obtain the best spring. On the other hand, the specifying of special compositions having only slight differences from a recognized standard chemical composition considerably increases the cost of the material and frequently makes it impossible to obtain the springs within a reasonable period of time. In the great majority of cases, a standard composition would satisfy the most exacting requirements. Later in this article a comparison of several approved chemical compositions is shown for each type of spring steel. In each case, one or two are recommended for general use.

Basic and Acid Steel Manufacture

In order to more fully understand spring steels, a general knowledge of methods of manufacture is required. Both basic and acid steels are made by the Bessemer, open-hearth or electric-furnace processes as follows:

Basic steel is made from iron containing a high percentage of phosphorus by adding limestone or other basic materials to absorb the acid phosphorus. The furnace is protected by a lining of basic materials such as magnesite or burned dolomite. This method produces steel of low phosphorus content from iron containing large percentages of this ubiquitous element. For some types of steel, such as hard-drawn spring steel, this method is used exclusively.

Acid steel is made from iron containing small percentages of phosphorus and sulphur by omitting the limestone customarily used in making basic steel, thus making the slag acid in character. The furnace is lined with silica sand which is also acid in nature. Music wire is always made from acid steel. An advantage of acid steel over basic steel is that the composition and nature of the slag is more easily controlled, thereby producing a more uniform quality of steel consistently over a long period of time.

Nearly all spring steels, except hard-drawn spring steel and music wire, may be made satisfactorily by either the basic or acid method. It has been noted, however, that at certain periods, the basic steels are more uniform and of better quality than the acid steels, and at other times the reverse is true. For this reason, it is best for manufacturing companies to widen their steel specifications to accept either basic or acid steels and allow the spring manufacturing companies to make the final selection.

Wire Manufacture

"Hard-Process" is a name given to a method of producing wire, whereby steel rods of fairly high hardness have their tensile strength and hardness increased by the cold work done on them in the process of reducing them to desired diameters by being cold drawn through hardened steel dies. A number of passes through dies gradually smaller in diameter produces wire to the desired size with very high tensile strengths. "Patented" hard drawn wire and music wire are drawn first through molten lead baths to give them a thorough high heat anneal above the critical temperature called a "patenting heat." They are then drawn through lower temperature lead baths to harden the wire preparatory to the cold drawing operation.

"Soft-Process" is a name given to a method of producing wire, whereby annealed steel rods are cold drawn through gradually smaller diameter dies with frequent anneals between passes until the desired diameter is reached; the wire is then hardened and tempered by the continuous method of heat treatment. In this final heat-treatment, the wire is drawn through molten lead baths at a temperature above the critical range and immediately quenched in either another lead bath hardly molten or in oil to harden the wire. The wire is then drawn through a third lead bath to draw the temper of the wire to the desired hardness. Oil-tempered carbon steel wire and oil-tempered chromium-vanadium wire are made by this method.

"Untempered" steel wire is made by the same method except that the hardening, quenching and temper-drawing heat-treatment is omitted. This type of wire leaves the last wire drawing die in a semi-hard condition which, for purposes of illustration, may be said to be half-way between a tempered wire and an annealed wire. Springs made from this wire are hardened and tempered by heat-treatment after coiling.

"Annealed" steel wire is also made by this same method except that as the untempered wire leaves the last drawing die it is given a subsequent anneal. Springs made from annealed wire are, of course, also hardened and tempered by heat-treatment after forming.

High Strength Springs

The ultimate aim in all spring design and manufacture is the production of springs with high tensile strengths, toughness and long fatigue life. Of the several means for attaining this end, four are of vital importance:

1. Added carbon content. Additional amounts, within reasonable limits, raise the tensile strength and hardness.

2. Alloying. Adding chromium, vanadium and other elements accomplishes certain features previously described.

3. Cold work. Cold working the wire, especially by drawing it through dies or by shot-blasting, considerably increases the properties desired on certain types of steel.

4. Heat-treatment. Correct heat-treatment, both during the wire manufacturing process and after the springs are made, is of vital importance.

Many claims of the importance of one of these methods over all others are frequently flouted, but the truth of the matter is that each one is important in itself and the best steels are produced by combining two or more of these methods. Springs made from the best steel obtainable will have a short fatigue life and prove unsatisfactory if improperly heat-treated, but even the best heat-treatment cannot materially improve defective wire.

In the description of the standard steels frequently used for springs, the

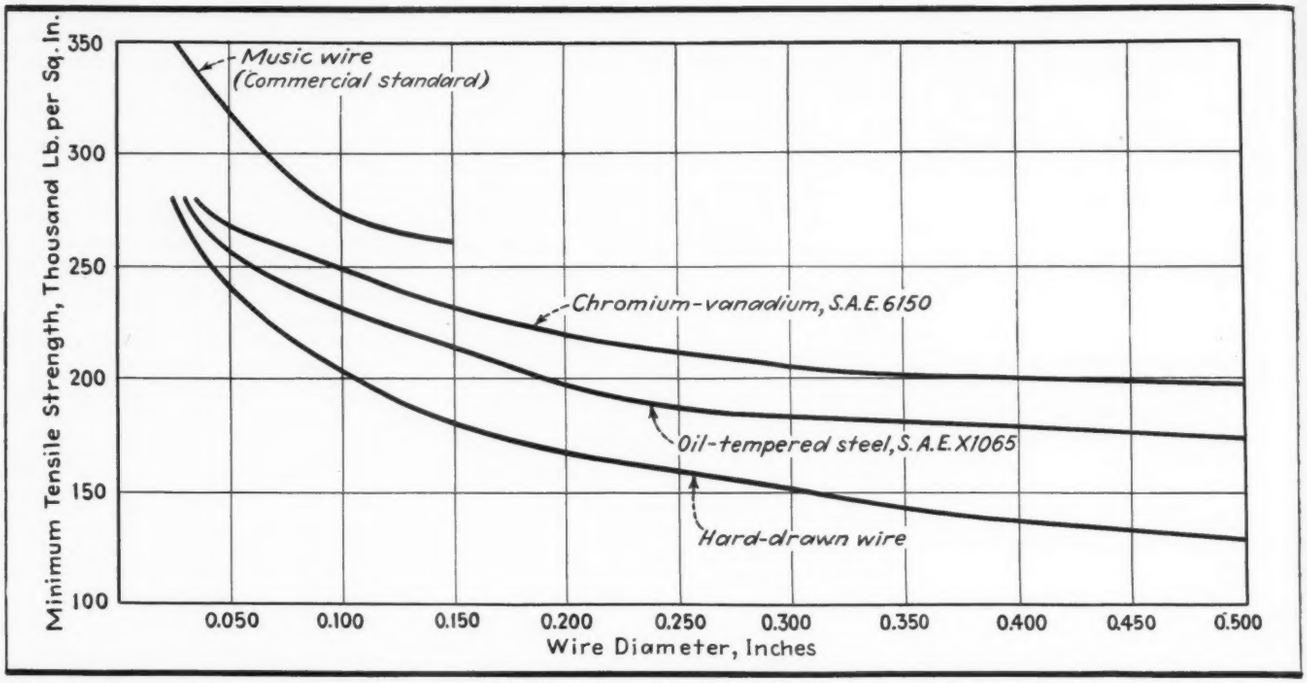


Fig. 1—Minimum tensile strengths of spring steels. All curves are plotted from minimum values shown in the tensile strength tables

Table I—Summary of Chemical Compositions and Applications of Standard Spring Steels

Type of Steel		Chemical Composition					Safe Working Stress		Rockwell Hardness	Modulus of Elasticity E — Tension G — Torsion	Application
		Carbon (per-cent)	Manganese (per-cent)	Phosphorus (per-cent)	Silicon (per-cent)	Sulphur (per-cent)	Type of Service	Lb. per sq. in.			
Hard-Drawn Spring Wire	S.A.E. 1350	0.45 to 0.55	0.90 to 1.20	0.040 Max.	0.15 to 0.30	0.050 Max.	Light	60,000		E = 28,500,000	For springs with relatively low stresses and having large tolerances on all dimensions and loads such as upholstery, bed and cushion springs. Use S.A.E. 1350 for wire dia. up to 0.100 in.
							Average	50,000			
	S.A.E. 1360	0.55 to 0.70	0.90 to 1.20	0.040 Max.	0.15 to 0.30	0.050 Max.	Severe	40,000		G = 11,400,000	
Music Wire	Special No. 1	0.80 to 0.90	0.25 to 0.35	0.025 Max.	0.15 to 0.25	0.025 Max.	Light	100,000	C 42 to C 46 For wire dia. over 0.100 in.	E = 30,000,000 G = 12,000,000 up to 0.100 in. dia. = 11,750,000 over 0.100 in. dia.	For all small springs of any real importance including springs for general machinery, motors, etc. and die springs. Standard wire diameters up to 1/8 in. and special sizes up to 5/16 in.
							Average	85,000			
	Special No. 2	0.85 to 0.95	0.25 to 0.45	0.025 Max.	0.15 to 0.30	0.025 Max.	Severe	70,000			
Oil-Tempered High Carbon Spring Steel S.A.E. X1065		0.60 to 0.75	0.90 to 1.20	0.040 Max.		0.055 Max.	Light	75,000	C 42 to C 46 Decreases with larger sizes	E = 28,500,000 G = 11,200,000	For all general springs with wire diameters from 1/32 up to 1/2 in. Also obtainable annealed. This is the most popular wire above 1/8 in. dia.
							Average	65,000			
							Severe	50,000			
Chromium-Vanadium Oil-Tempered or Annealed S.A.E. 6150		0.45 to 0.55	0.60 to 0.90	0.040 Max.	0.15 to 0.30	0.050 Max.	Light	80,000	C 42 to C 50	E = 30,000,000 G = 11,200,000	For special springs subjected to impact or shock loads such as motor valve springs and die springs with wire diameters from 1/32 up to 1/2 in.
		Chromium—0.80–1.10, Vanadium—0.18%					Average	70,000			
							Severe	55,000			
Silicon-Manganese Annealed S.A.E. 9260		0.55 to 0.65	0.60 to 0.90	0.040 Max.	1.80 to 2.20	0.050 Max.	Light	75,000	C 42 to C 46	E = 29,000,000 G = 10,750,000	To be used as a substitute for chromium-vanadium. Recommended in large wire diameters above 3/8 in. only and for flat leaf eliptical springs.
							Average	65,000			
							Severe	50,000			

information most generally required by spring designers is stressed and all data not pertinent to spring design is omitted. All of the A.S.T.M. specifications described in this article became standard without revision late in 1941 and can be found listed under the same numbers as 1939 Tentative Standards in existing A.S.T.M. publications, or as standards in the new 1941 supplement.

Safe Working Stress

Table I of physical properties and chemical compositions shows a recommended "safe working stress" for each material. Values of this nature are variable and depend upon such qualifications as type of springs, atmosphere, temperature, ratio of outside diameter to wire diameter, rapidity and regularity of deflections, shock loads, wire size and stress range. The values listed are for compression and extension springs not subjected to high temperatures, shock loads, etc. Three values are shown for each material, based upon light, average or severe service and these values have proved themselves effective over a long period of service for normal spring applications. For wire sizes, under 0.045 in. dia., the values may be increased 10 percent; for torsion springs or flat cantilever springs, increased 25 percent; but for suddenly applied loads, all stresses should be reduced 50 percent. These stress values also include allowances for curvature correction factors. Therefore, the stress in the spring due to the load (or caused by deflection) multiplied by the curvature correction factor based upon the spring index, should not exceed the values listed.

Hard-Drawn Steel Spring Wire

Hard-drawn steel spring wire is a fairly good quality, medium carbon steel, obtainable in sizes up to ½ in. dia. It has the lowest amount of carbon of any straight-carbon spring steel and is the least expensive grade of steel wire suitable for spring use. Its color is a mixture of gray and dusty black having little lustre.

MANUFACTURE. This wire is a basic, open-hearth, domestic steel. It receives its hardness and tensile strength by cold drawing through hardened steel dies, and is not used for springs in the annealed condition.

APPLICATION. Hard-drawn steel spring wire was developed primarily for automobile cushion and seat springs and for general upholstery and bed springs. It is recommended for those applications and for all types of coiled springs having low stresses and where accuracy of wire and spring diameters need not be too closely held. It is frequently used also for wire tubing. It may be obtained readily in many gage sizes from 0.060 in. to 0.1875 in. dia., in special sizes from 0.190 in. to ½ in. dia., and in square sizes on special order.

CHEMICAL COMPOSITION. There are several specifications for hard-drawn steel spring wire. No one specification should be used for all wire sizes in as much as it is desirable to increase the carbon content in the larger wire diameters so that more uniform values of hardness and tensile strengths may be obtained. The most popular specifications, as shown in Table II, are S.A.E. 1350 and S.A.E. 1360 spring steels.

Table II—Compositions of Hard-Drawn Steel Wire

Composition	S.A.E. 1350 0.025 to 0.100 in. Dia.	S.A.E. 1360 Over 0.100 in. Dia.	S.A.E. X1055 All Dia.	A.S.T.M. A227–41
Carbon.....	0.45–0.55%	0.55–0.70%	0.50–0.60%	0.45–0.75%
Manganese...	0.90–1.20%	0.90–1.20%	0.90–1.20%	0.60–1.20%
Silicon.....	0.15–0.30%	0.15–0.30%	.....	0.10–0.30%
Phosphorus..	0.040% max.	0.040% max.	0.040% max.	0.045% max.
Sulphur.....	0.050% max.	0.050% max.	0.055% max.	0.050% max.

NOTE: A.S.T.M. A227–41 is a general specification only and is flexible. Carbon ranges in spring steel specifications should not vary more than 10 points nor should manganese ranges vary more than 30 points. It may be seen, therefore, that in purchasing steel wire to this specification, it is necessary to state the exact ranges of both carbon and manganese contents desired; thus, wire may be obtained with the same composition as the S.A.E. steels listed.

Table III—Physical Properties of Hard-Drawn Steel Wire

Elastic Limit in Tension: % of Tensile Strength.....	60 to 70%
Elastic Limit in Torsion: % of Tensile Strength.....	45 to 55%
Modulus of Elasticity in Tension, *E*.....	28,500,000
Modulus of Elasticity in Torsion, *G*.....	11,400,000
Weight, lb. per cu. in.....	0.284 lb.
Elongation in 2 in., approx.....	5%

TENSILE STRENGTH varies with wire diameters. Sizes under 0.100 in. have higher tensiles than the larger sizes. Two tables are shown. Table IV (A) is an average made from actual test results on wire produced by several manufacturers; Table IV (B) is the requirement for A.S.T.M. A227-41.

Table IV—Tensile Strength of Hard-Drawn Steel Wire

(A) AVERAGE OF MANUFACTURERS

Wire Dia. in.	Tensile Strength, lb. per sq. in.	
	Min.	Max.
0.025	280,000	305,000
0.050	240,000	265,000
0.075	225,000	250,000
0.100	200,000	225,000
0.125	190,000	215,000
0.1875	170,000	195,000
0.250	160,000	185,000
0.3125	150,000	175,000
0.375	140,000	165,000
0.4375	135,000	160,000
0.500	130,000	155,000

(B) A.S.T.M. A227–41

0.028	260,000	310,000
0.054	230,000	274,000
0.072	215,000	260,000
0.105	200,000	242,000
0.120	195,000	237,000
0.148	186,000	228,000
0.177	180,000	220,000
0.207	172,000	214,000
0.250	167,000	208,000
0.3125	160,000	200,000
Over 0.3125	150,000	190,000

NOTE: Steel wire purchased to A.S.T.M. A227–41 must have a tensile strength within the range listed in Table IV (B), but a single lot must not vary more than 40,000 lb. per sq. in. in sizes 0.072 in. and finer, nor more than 30,000 lb. per sq. in. for sizes coarser than 0.072 in. Most manufacturers encounter no serious difficulties in keeping the range within a 25,000 lb. per sq. in. limitation and most commercial wire will meet the values shown in Table IV (A).

TOLERANCES, on wire diameter or side of square are as follows:

Hard-Drawn Wire Tolerances

Wire Size	Plus or Minus
Up to 0.100 in.....	0.001 in.
0.101 to 0.1875 in.....	0.0015 in.
0.188 to 0.375 in.....	0.002 in.
0.376 to 0.500 in.....	0.0025 in.

PRICE. An average price in 1940, in quantities of 500 pounds, varied from 4 cents to 6 cents per pound, depending upon the wire size.

[*Next month*—Data covering music wire, oil-tempered, chromium-vanadium, and silicon-manganese steels.]

Modern Designs

Aluminum Eliminated, Bus Weight Is Reduced

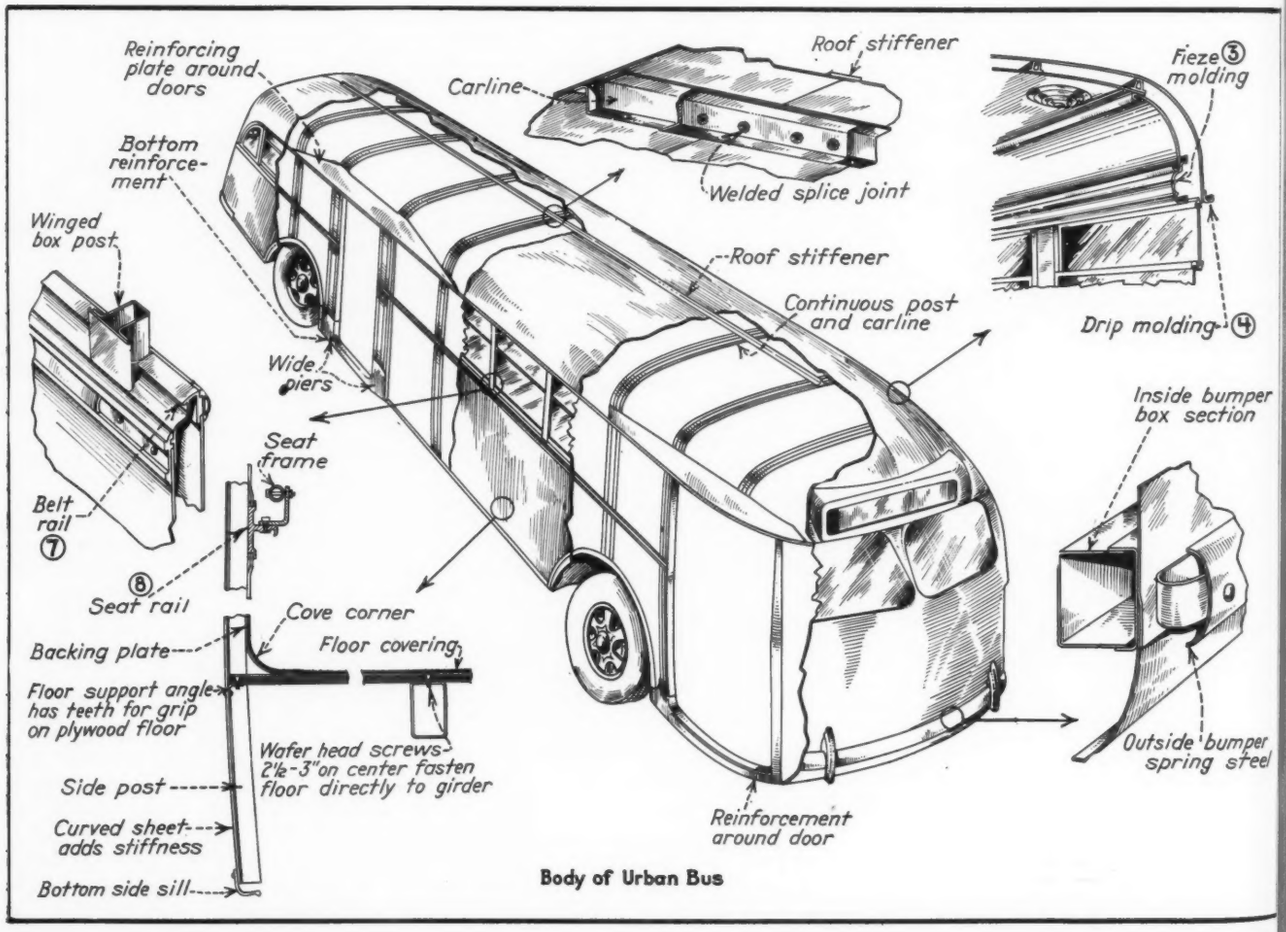
When aluminum shortage struck, J. G. Brill Company was making urban buses and parlor coaches with aluminum bodies. If steel were substituted section for section, typical 37-passenger bus would weigh 6,000 lb. more. Consequently, the Brill Company began thorough redesign. Result now going into production: all-steel, "stressed-skin" body construction with welded frame. Steel coach (37-passenger, air-conditioned) is 2,000 lb. lighter than equivalent 22,000-lb. aluminum coach.

Details of body show how members of welded frame and steel skin "dissipated" stresses into all adjoining members. Posts and carlines are flared channel sections which extend to center of roof where welded joint is made so that damages to one side can be repaired without disturbing other side. Door frames are reinforced top and bottom and have double-post piers at sides. Reason: interruption of stressed skin and belt necessitates reinforcement to help carry stresses being transferred around doors.

Double belt is interrupted only at doors. Bottom side sill is curved steel section. Plywood floor is screwed to frame by wafer-head, self-tapping screws set about 3 in. apart. Weight of body was reduced in redesign to point where it was possible to use a 605-cu.in. Hall-Scott engine instead of former 707-cu.in. engine. Smaller clutch, transmission, axles, wheels and tires made further weight saving.

In contrast to intercity coach shown opposite, urban bus (below) has door at front so passengers enter near operator. By setting door behind front wheels in intercity coach, wheelbase is lengthened for better high-speed riding.

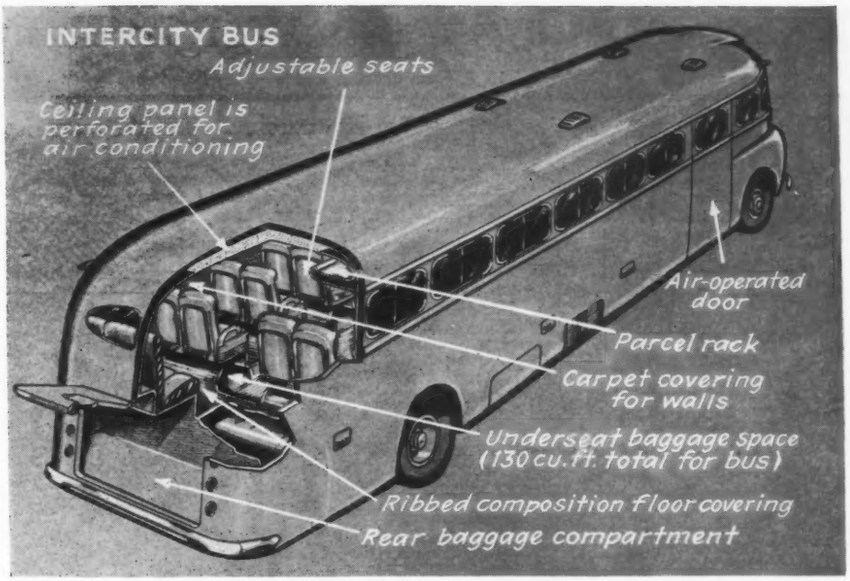
Many body parts are continuous strips. Formerly these were extruded aluminum, but they have been replaced by steel draw-bench shapes spot-welded together, plastics, or other steel shapes. Numbers in circles indicate specific design changes shown on pages 8 and 9.



Body of Urban Bus

Skin sheets of steel body are 0.05 in. thick; previous skin was aluminum 0.078 in. thick. Thickness of steel is greater than required for strength, but is necessary to avoid wavy appearance of flat panels of thinner sheets. Interior panels not a part of the monocoque construction were formerly of aluminum. Aluminum sheets could easily be "bumped" into double curvatures. Fybr-Tech pressed wood has been substituted in seat-foot parts, parcel racks, "modesty" shield in front of first seat; thin steel sheet in roof and side panels.

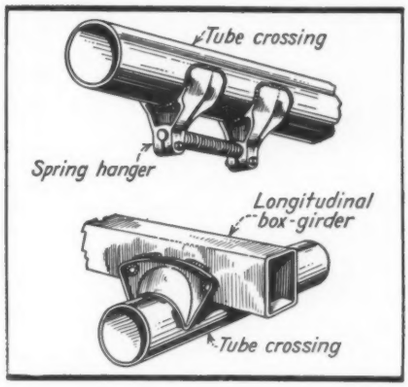
Alternates now under consideration for internal panels are fabric-backed thermoplastic sheets which can easily be formed by heating; Fybr-Tech, Masonite, and formed panels made from resin-impregnated sisal fibres. Principal requirement is smooth, flat surface and easy formability.

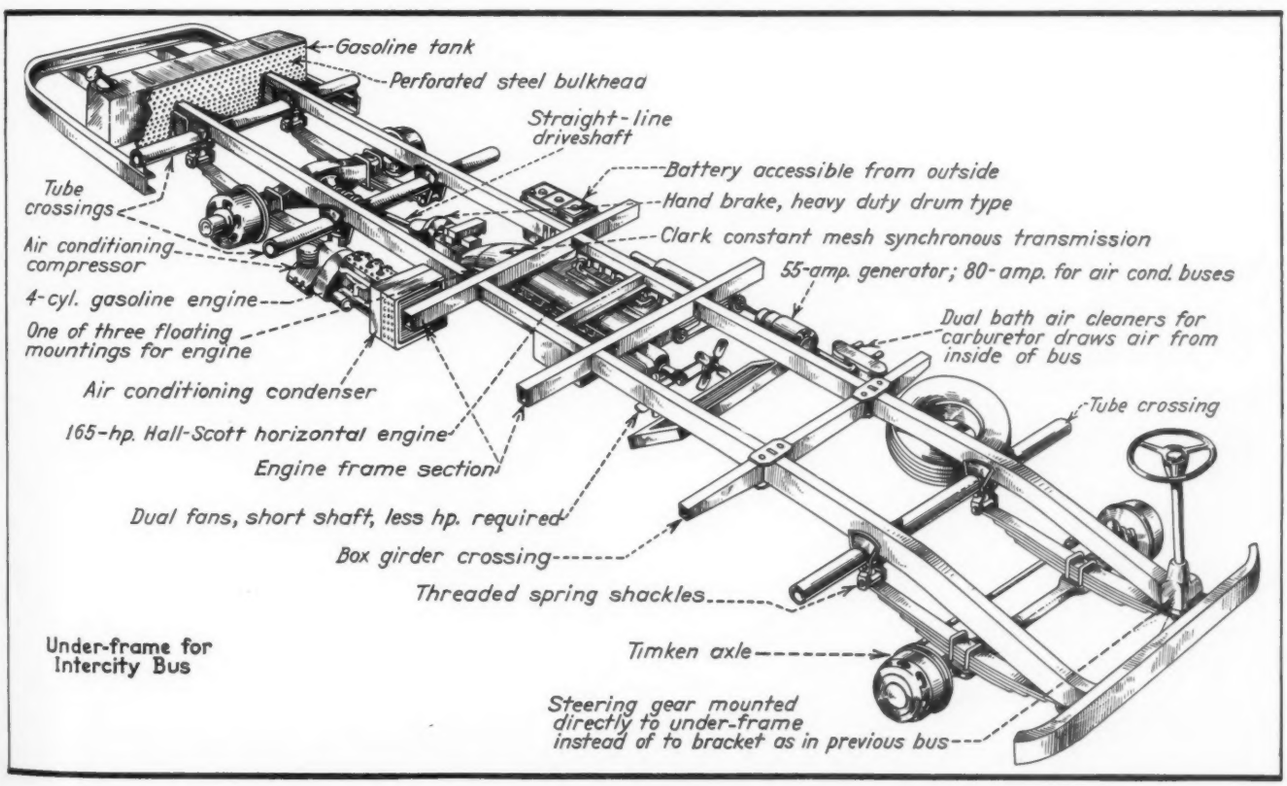


Welded box and tube underframe eliminates rivets, gussets, braces and heavy spring brackets of previous frame. Main joints, except for one crossing, are formed as shown at right without interrupting box-girders or tubular crossings. Longitudinal members are interrupted only by frame in which engine is mounted. Longer or shorter bus frames are made by welding on longer or shorter longitudinal members ahead of the standard engine section. Frame shown is for intercity bus.

Perforated sheet in front of gas tank is another example of weight-saving. Consequently, in many such applications sheets are specified 0.05 in. thick, but are perforated so they have only 50 percent of original cross-section. Perforated sheets are installed wherever a body panel must have both strength and stiffness, but need not be solid. Because appearance of perforated sheet is not unattractive, they may be used more in interior panels. Thin sheets now used in roof of air-conditioned bus are perforated over entire area to distribute clean conditioned air from under-the-roof duct, and to deaden sound.

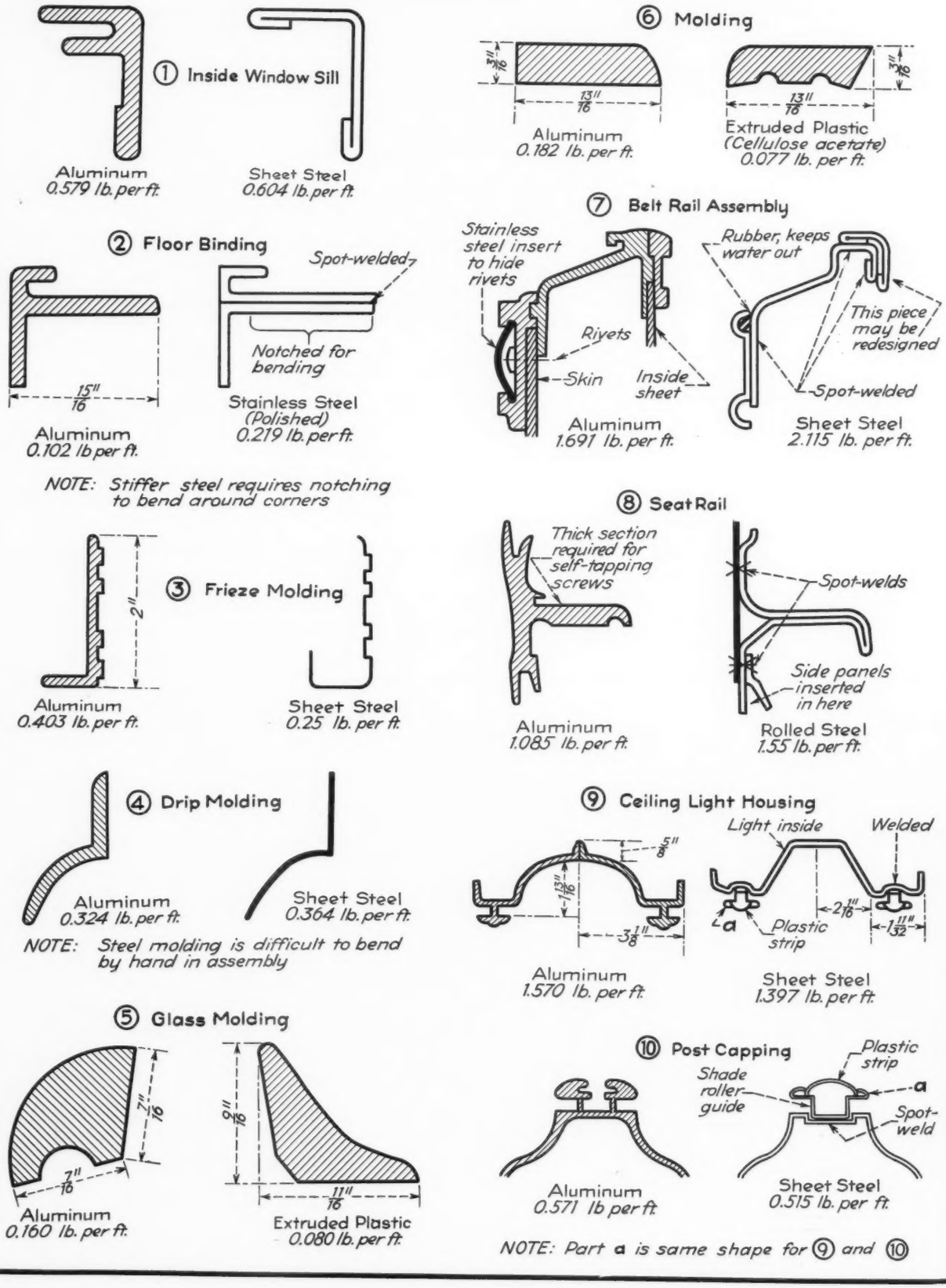
(Continued on next page)



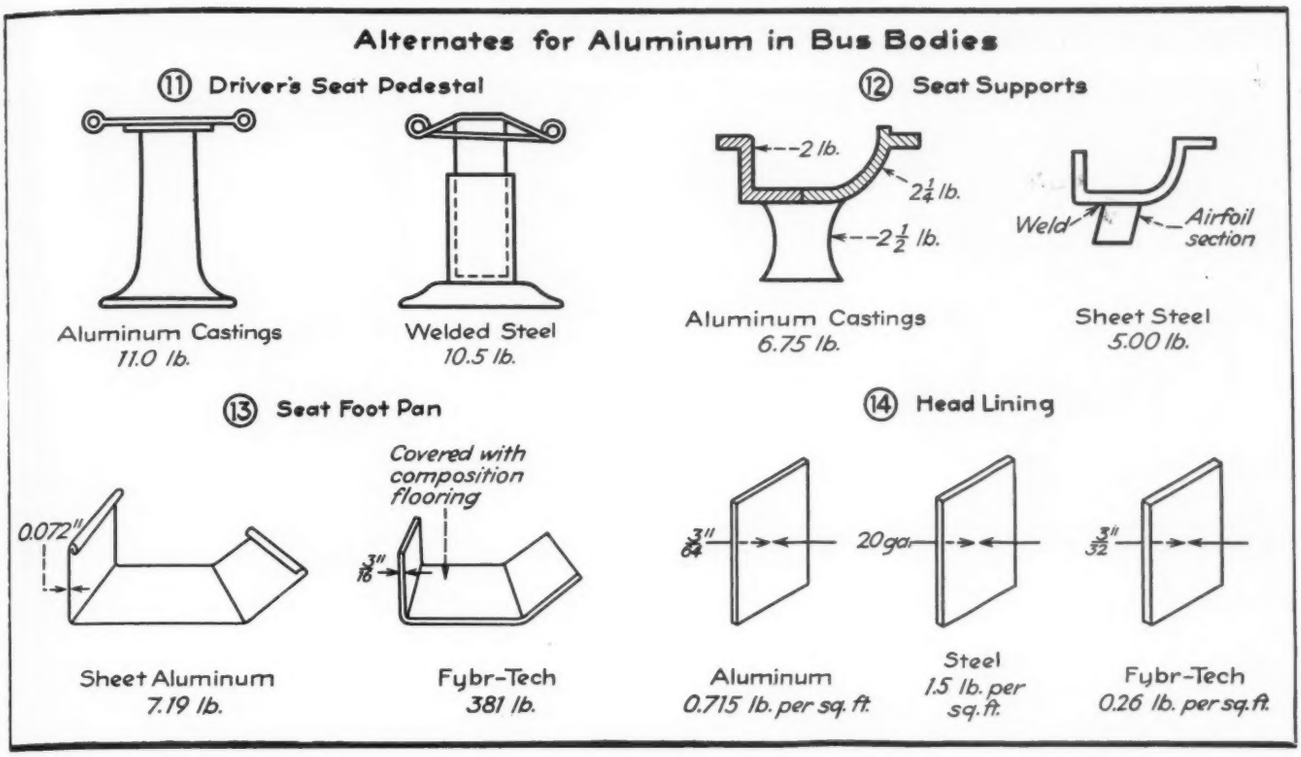

Gasoline tank
Perforated steel bulkhead
Straight-line driveshaft
Battery accessible from outside
Hand brake, heavy duty drum type
Clark constant mesh synchronous transmission
55-amp. generator; 80-amp. for air cond. buses
Dual bath air cleaners for carburetor draws air from inside of bus
Tube crossing
Tube crossings
Air conditioning compressor
4-cyl. gasoline engine
One of three floating mountings for engine
Air conditioning condenser
165-hp. Hall-Scott horizontal engine
Engine frame section
Dual fans, short shaft, less hp. required
Box girder crossing
Threaded spring shackles
Timken axle
Steering gear mounted directly to under-frame instead of to bracket as in previous bus

Under-frame for Intercity Bus

Alternates for Extruded Aluminum in Bus Bodies

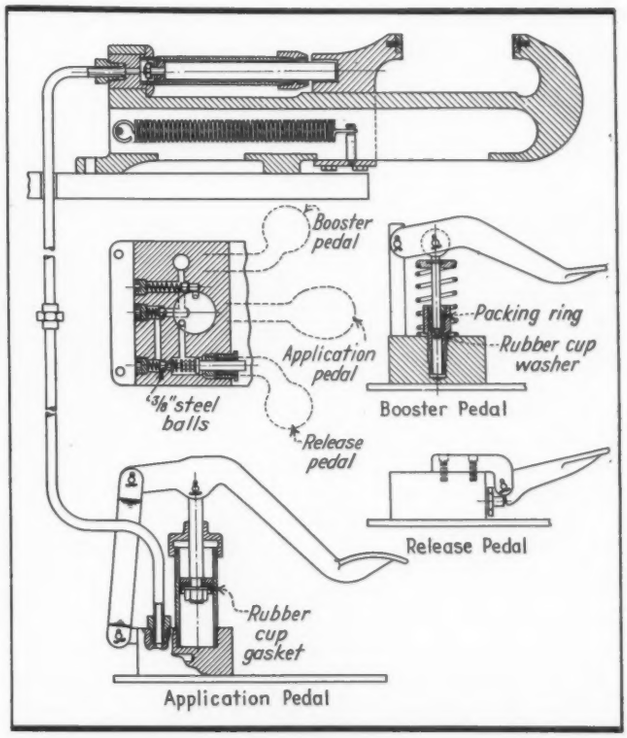


Alternates for Aluminum in Bus Bodies

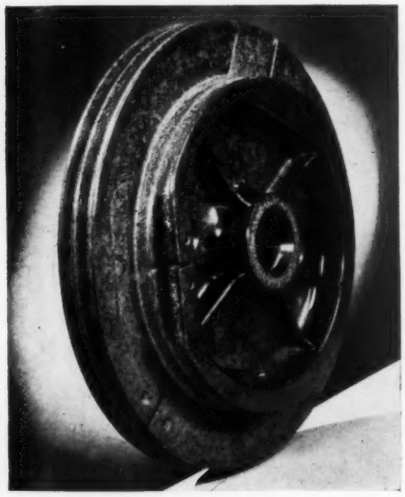


Hydraulic Vise Operated by Foot Valve Pump

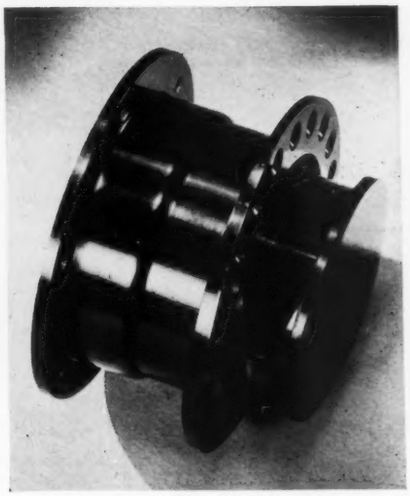
Three-pedal, foot-operated pump of Studebaker Hydraulic Visepress attains holding pressure between jaws as high as 5 tons. Stepping on middle pedal brings jaw up to grip work lightly; shifting foot to pedal at right applies holding pressure, and third pedal releases jaw. Jaw is spring-returned, the hydraulic fluid being forced back through the pedal-opened ball check valve into cylinders. Vise and foot pump are semi-steel castings. Tubing is seamless steel. Pump and ram cylinders are honed and polished. Spring-loaded, ⅜-in. dia. steel ball check valves in spherical seats prevent loss of holding pressure. Ram is on center line of jaw for direct force.



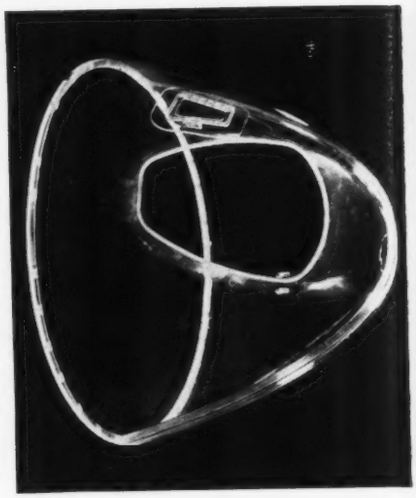
MODERN DESIGNS – Plastics in Fighting Aircraft



Macerated fabric as filler for molded phenolic plastics gave high strength to this control quadrant for Martin bomber. Aluminum counterpart would weigh nearly 20 percent more.

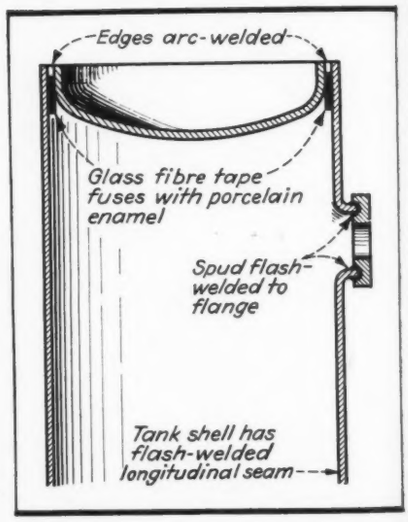


Cabin ventilator molded to intricate shape of phenolic compound, can be quickly adjusted to scoop in or exhaust air, or remain closed. Corrosion would be problem with other materials.



Acrylic resin bomber nose section is designed to withstand airblasts at 400 m.p.h., and supports machine gun. All three examples shown here were winners in the Modern Plastics contest.

Welded Tank Enameled Inside and Out


Edges arc-welded
Glass fibre tape fuses with porcelain enamel
Spud flash-welded to flange
Tank shell has flash-welded longitudinal seam

One-piece welded construction of hot water tanks porcelain-enameled inside and out indicates possible use of porcelain enameled steel as alternate for stainless steel, copper, galvanized steel and other corrosion-resistant metals in similar applications. Development of this tank began in 1880, but had to wait until right steel, porcelain enamel tough enough to withstand pressure and corrosion, and welding technique were perfected. Steps in production at Porcelain Steels, Inc., are: roll Armco Ingot Iron sheets into cylinder; flash-weld longitudinal seam in 18-ton automatic welder; grind seam smooth; punch, ream holes and extrude shell metal to form spud flanges; flash-weld spuds to flanges; pickle; dip in ground coat of porcelain enamel, brush ends and fire at 1,650 deg. F.; spray on finish coat of enamel, brush ends and fire at 1,650 deg. F.; arc-weld porcelain enameled dished heads to tank; and inspect under pressure as shown above. Base coat of enamel has good bond to etched metal.

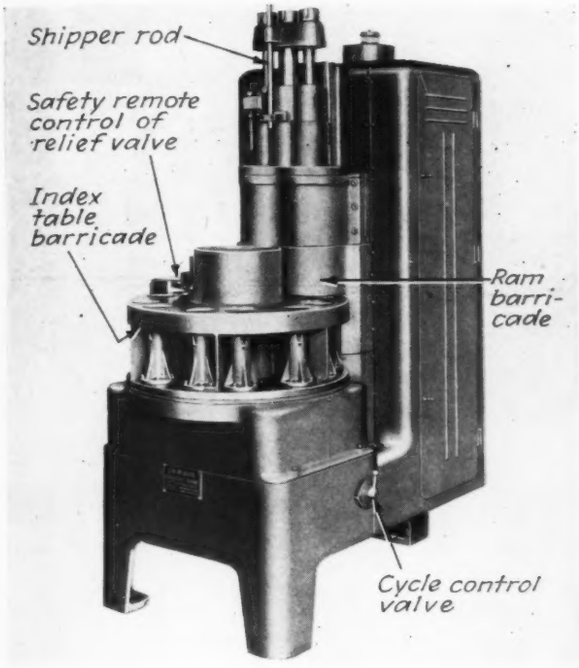
Uninterrupted porcelain coating across welded joint at heads is achieved by placing 2-in. wide strip of glass fibre between tank and head before welding. Heat of welding fuses glass and porcelain inside tank. Edges of tank and heads are brushed after enameling coating to give clean metal surfaces for welding. Flash welding of longitudinal seam (before enameling) takes 10 sec., burns off $\frac{3}{8}$ to $\frac{5}{8}$ in. of metal, results in seam as strong as parent metal. Tanks for pressures ranging from 250 to 400 lb. per sq. in. are made from sheet metal ranging from 3 to 14 gage. Cost is less than for copper tank.

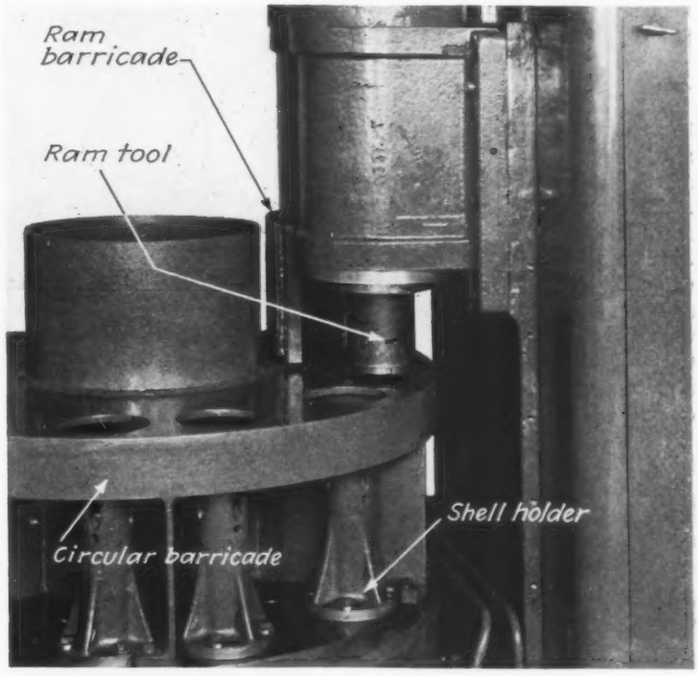
Interlocked Controls Reduce Explosion Hazard

Hydraulic interlock between 6-station indexing unit and dual rams, and welded steel circular barricade give two-way protection against premature explosions in this Denison HydrOilic powder-consolidating press. Dual rams cannot move down until indexing table is locked in position, nor can indexing occur until rams have moved up. Presses, in 5 and 15-ton sizes for handling shell from 20 mm. to 60 mm., turn out 30 to 40 shells per min.

Control is through interlock within ram cylinders. Hydraulic dual cylinders rapid-traverse down to any position determined by shipper rod adjustment, then slowly descend until they touch powder in shell. Hydraulic circuit equalizes pressure of rams as they apply pre-determined pressure, sometimes with 2 to 6-sec. dwell, to the two shells. Both rams rapid-reverse after pressure is applied. When rams are fully raised, interlock pulls index table lock, table cylinder indexes table through gears, table is locked, and cylinders repeat cycle. Four-way control valve is cam-operated for positive automatic cycling. Valve and interlock are not affected by foreign matter in oil.

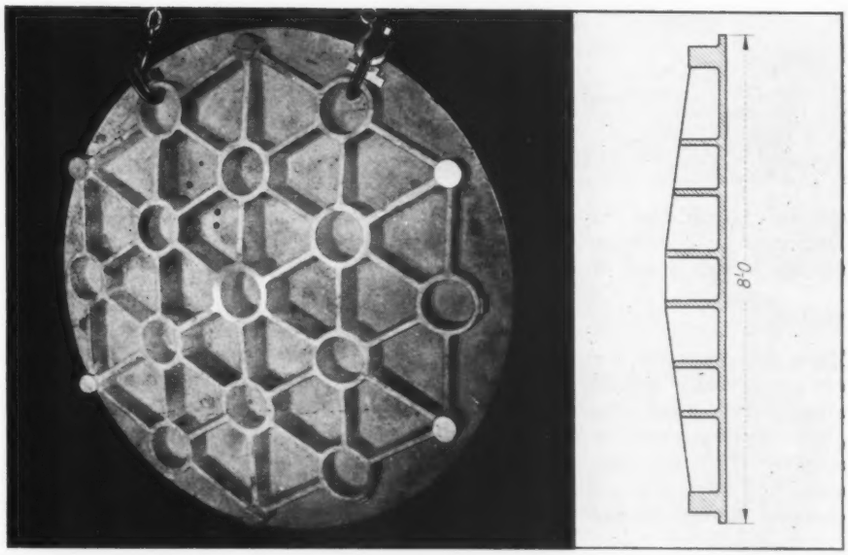
Three manual valves permit indexing the table during tool set-up, but table will not index unless rams are locked in up position. Similarly, rams may be "inched" if table is locked in position. When shell is improperly placed in holder, shell contacts a safety valve which unloads a master relief-valve to halt press operation.





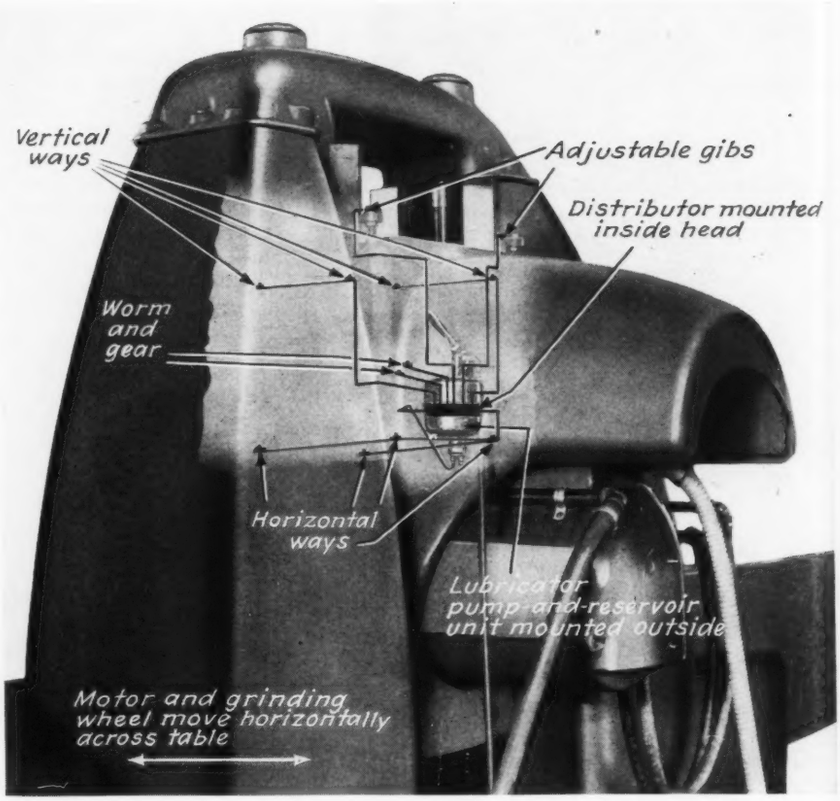
Large Surface Plate Has Unusual Design

Design problem for large surface plate (96 in. dia.) was to equalize casting stresses and at same time obtain permanent trueness after turning and grinding. Size prohibited normalizing so plate was finished in as-cast condition. Ribs on bottom were spaced so that they are nearly uniform in length. Top is comparatively thin for good proportion between cross-sections of ribs and top. Plate was cast of type GA Meehanite and weighs about 6,700 lb. Machining sequence was: face off supports; turn outer edge; turn plate over and rough-turn top surface; finish-turn top surface. Surface was checked after machining and was found to be holding true and accurate. Supported on one central and six peripheral supports resting on concrete piers, it has maintained accuracy for more than a year in service.

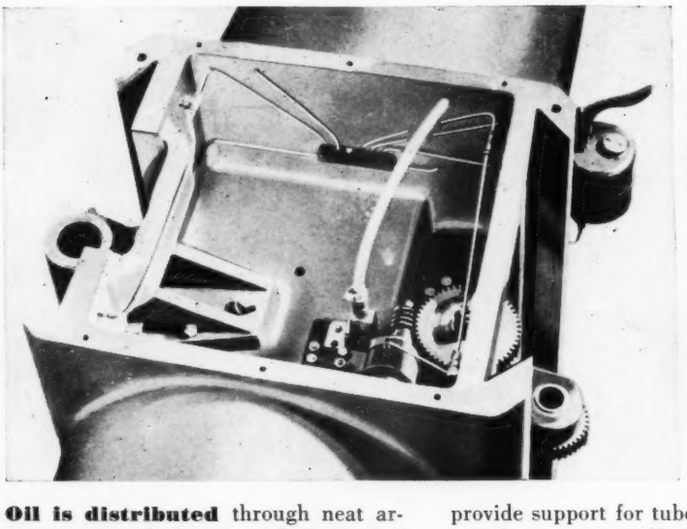


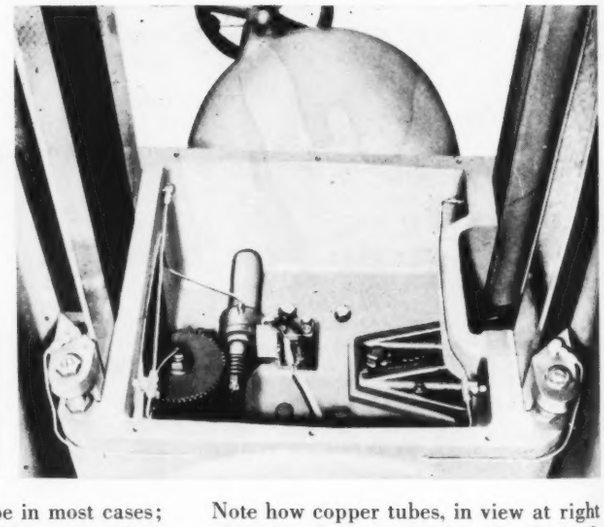
MODERN DESIGNS – Lubricator Mounted on Wheel Head

Moving wheel head unit of high-powered precision grinder has eight-surface ways for vertical and wheel slide assembly, which together with tapered gibs, horizontal ways, and bearings in feed drive, call for lubrication of 13 bearing surfaces in the wheel-head unit. Engineers of Mattison Machine Works meet this lubricating problem with a one-shot system that rides with the head.



Pump and reservoir unit, with filter, is mounted on back of wheel head unit as shown. When pump lever is cocked, metered oil is fed through tube to distribution block mounted inside wheel head. Seven branch lines carry oil to Bijur meter units which feed oil directly to bearing surfaces. Vertical ways have zig-zag oil grooves for distributing oil over entire surface. Phantom view at right shows lubricating circuit, lubricator, and distributor.





Oil is distributed through neat arrangement of junction fittings and tubing inside wheel head. Fittings provide support for tube in most cases; in other cases small clips screwed to wheel head casting support the tubes. Note how copper tubes, in view at right above, are bent around outside of wheel-head to fittings on tapered gibs.

PORTABLE HYDRAULIC TEST UNIT for testing aircraft hydraulic systems is about the size and shape of a spinet piano. Cabinet, mounted on casters, is a plywood-covered unit with frame welded of angle iron. Top of cabinet contains sloping instrument and valve panel, and stainless steel sink.

SYNTHETIC RUBBER is being groomed to replace natural rubber in feed rolls for typewriters as soon as the present shortage of synthetic is relieved. Natural rubber, exposed to stencil wax, fatty acids and oils of ribbon inks and carbon paper compounds, sometimes swells and softens, causing smudge marks.

AT ARMY'S INSTIGATION, aluminum cases for Army radios are now made of sheet steel. For corrosion-resistance, steel is copper plated, assembled by welding and riveting, copper plated a second time to protect joints, and finished with zinc chromate primer and regulation Signal Corps enamel finish.

DIFFERENCE CALCULUS

Simplifies Computation of Shaft Deflections

A. H. CHURCH
New York University, College of Engineering

DIFFERENCE CALCULUS is an approximate method of integration that may be used with a surprising degree of accuracy when strictly mathematical methods would be impossible or too cumbersome. The principle is not new, being used in photoelectric work, vibration studies and a variety of other ways. It is a powerful tool which may be used wherever an integration is involved, particularly if the functions do not have constant mathematical relations with each other. Once the general method of attack has been determined for a given type of problem, it may be used for all problems of this type, regardless of the manner in which the functions vary.

The method is based on the principle that the value of an integral at any point is equal to the summation of the small values of the integral up to that point, or, if we know the value of an integral or function at one point, we can find its value at another point by adding algebraically to the known value the difference in values between the two points.

To illustrate its application to a particular case, consider the determination of the deflection curve of beams having non-uniform cross-sections. This is done for a cantilever beam with a concentrated load at and for a simply supported shaft having two concentrated loads and including the deflection due to its own weight.

The symbols and their units are:

b=width of beam at point x, in.
d=shaft diameter at point x, in.
E=modulus of elasticity, lb. per sq. in.
I=moment of inertia, (in.)
M=bending moment of beam, in. lb.
p=load on beam or section, lb.
t=depth of beam at point x, in.
V=shear on beam at point x, lb.
x=distance measured along beam to any section, in.
Δx=length of section assumed for integrating, in.
y=deflection at point x, in.

Deflections of Cantilever Beam

EXAMPLE I. To find the deflections along the steel cantilever beam shown in Fig. 1 due to the concentrated load P of 2,000 lb., neglecting beam weight.

The beam is divided into a number of sections of length Δx. The value of Δx to be assumed depends upon the accuracy desired. In this case it is taken as constant and equal to 2 in. and the distance x is measured from the load to the section considered.

Applying the principle of difference calculus to the well known deflection equations, the following equations are developed:

$$\frac{d^2y}{dx^2} = \frac{M}{EI} = \frac{Px}{EI}$$

$$\frac{dy}{dx} = \frac{P}{EI}\,\Sigma x\Delta x = \text{slope of elastic curve}$$

$$y = \frac{P}{E}\,\Sigma\Delta x\,\frac{1}{I}\,\Sigma x\Delta x$$

$$= \frac{P}{E}\,\Sigma\Delta x\,\frac{12}{bt^3}\,\Sigma x\Delta x$$

$$= \frac{12P}{E}\,\Sigma\Delta x\,\frac{1}{bt^3}\,\Sigma x\Delta x$$

The most convenient method of solving the last equation is by means of a table, such as Table I, which may be set up and filled in. The values of b and t at the midpoints of the sections are scaled from the drawing, if necessary, and listed in columns 2 and 4. The values of $x\Delta x$ are found by multiplying Δx, 2 in., by the values of x at the midpoints, and these are integrated in column 6 by starting at the fixed end (x=20), as the slope here is zero, and

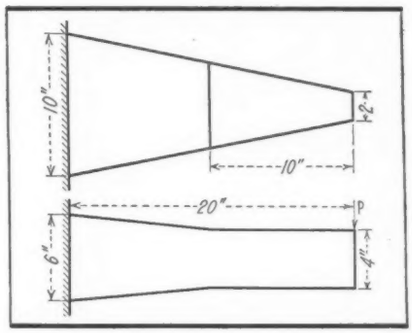


Fig. 1—Deflections of this cantilever beam due to a concentrated load are easily determined by difference calculus

Table I — Solution for Beam Deflections

1		3	4	5	6	7	8	9	10
X	t	t^3	b	$X\Delta X$	$\Sigma X\Delta X$	$\Sigma X\Delta X$	$\frac{\Delta X}{bt^3}\Sigma X\Delta X$	$\sum\frac{\Delta X}{bt^3}\Sigma X\Delta X$	y
0	4.0	64.00	2.0		200			9.167	0.00733
1	4.0	64.00	2.4	2		199	2.590		
2					198			6.577	0.00526
	4.0	64.00	3.2	6		195	1.905		
4					192			4.672	0.00374
	4.0	64.00	4.0	10		187	1.460		
6					182			3.212	0.00257
	4.0	64.00	4.8	14		175	1.139		
8					168			2.073	0.00166
	4.0	64.00	5.6	18		159	0.886		
10					150			1.187	0.00095
	4.2	74.09	6.4	22		139	0.586		
12					128			0.601	0.00048
	4.6	97.34	7.2	26		115	0.328		
14					102			0.273	0.00022
	5.0	125.00	8.0	30		87	0.174		
16					72			0.099	0.00008
	5.4	157.50	8.8	34		55	0.079		
18					38			0.020	0.00002
	5.8	195.10	9.6	38		19	0.020		
20	6.0		10.0		0			0	0

Table II — Solution for Shaft Deflections

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
X	d	P	V	V	$V\Delta X$	$\frac{M}{\Sigma V\Delta X}$	M	d^4	$\frac{M}{d^4}$	$\frac{M}{d^4}\Delta X$	$\sum\frac{M}{d^4}\Delta X$	S	$S\Delta X$	$\Sigma S\Delta X$	$\frac{T}{30}X$	$\frac{TX}{30}-\Sigma S\Delta X$	y
$\frac{R}{0}$			43.10			0					0			$\frac{R}{0}$	0	0	0
0	7/8	0.51		42.85	128.55		64.28	0.586	109.7	329.1		164.6	494				
3			42.59			128.55					329.1			494	9,717	9,223	0.00625
	1	0.67		42.26	126.78		191.94	1.000	191.9	575.7		617.0	1,851				
6			41.92			255.33					904.8			2,345	19,410	17,065	0.01157
	1	0.67		41.59	124.77		317.72	1.000	317.7	953.1		1,381.4	4,145				
9		30.00	41.25			380.10					1,857.9			6,490	29,150	22,660	0.01538
	1	0.44	11.25	11.03	22.06		391.13	1.000	391.1	782.2		2,249.0	4,498				
11			10.81			402.16					2,640.1			10,988	35,600	24,612	0.01670
	1 1/4	1.05		10.29	30.87		417.60	2.442	170.7	512.1		2,896.2	8,689				
14			9.76			433.03					3,152.2			19,677	45,300	25,623	0.01739
	1 1/4	1.05		9.24	27.72		446.89	2.442	183.0	549.0		3,426.7	10,280				
17			8.71			460.75					3,701.2			29,957	55,050	25,093	0.01701
	1 1/8	0.57		8.43	16.86		469.18	1.600	293.5	587.0		3,994.7	7,990				
19		50.00	8.14			477.61					4,288.2			37,947	61,500	23,553	0.01597
	1 1/8	0.57		−42.15	−84.30		435.46	1.600	272.0	544.0		4,560.2	9,120				
21			−41.86			393.31					4,832.2			47,067	68,000	20,933	0.01420
	1 1/8	0.85		−42.86	−128.58		329.02	1.600	205.7	617.1		5,140.8	15,423				
24			−42.43			264.73					5,449.3			62,490	77,700	15,210	0.01032
	1 1/8	0.85		−43.71	−131.13		199.17	1.600	124.7	374.1		5,636.4	16,910				
27			−43.28			133.60					5,823.4			79,400	87,450	8,050	0.00546
	1	0.67		−44.47	−133.41		66.90	1.000	66.9	200.7		5,923.8	17,770				
$\frac{L}{30}$			−44.80			0.19					6,024.1			$\frac{T}{97,170}$	97,170	0	0

adding up the successive values of $x\Delta x$. The values of $x\Delta x$ at the midpoints of the sections are found by averaging the values at the ends of the sections, and are placed in column 7.

It would be more exact to plot a curve of column 6 against x and read off mean ordinates for column 7, but if Δx is made reasonably small this refinement is unnecessary. Values in column 8 are found by multiplying those in column 7 by Δx, 2 in., and dividing by the values of b and t^3 of columns 3 and 4. These are summed up as before, starting at the fixed end ($x=20$) as the deflection there is zero. Multiplying these values by the constant 12 P/E which is 0.0008 for $E=30{,}000{,}000$, gives the actual deflection in inches at points along the beam. These may be plotted to obtain intermediate values.

It is not necessary that all the Δx sections be the same length, although it is usually more convenient to make them so. It should be noted that the method can be used just as easily if the surfaces of the beam are irregularly curved rather than plane.

Deflections of Shaft

EXAMPLE II. To find the deflections along a simply supported steel shaft due to its own weight and two concentrated loads as shown in Fig. 2.

This problem is more general than the previous one since the shear is not constant along the beam, and the point of zero slope is not obvious. The distance x may be measured from either support. In this example it is taken as the distance from the right support R.

Again applying the principle of difference calculus to the deflection equations, the following equations result:

$$\frac{d^3y}{dx^3}=\frac{V}{EI}$$

$$\frac{d^2y}{dx^2}=\frac{1}{EI}\Sigma V\Delta x$$

$$\frac{dy}{dx}=\frac{1}{E}\Sigma\Delta x\frac{1}{I}\Sigma V\Delta x=\text{slope of elastic curve}$$

$$y=\frac{1}{E}\Sigma\Delta x\Sigma\Delta x\frac{1}{I}\Sigma V\Delta x$$

$$=\frac{1}{E}\Sigma\Delta x\Sigma\Delta x\frac{64}{\pi d^4}\Sigma V\Delta x$$

$$=\frac{64}{\pi E}\Sigma\Delta x\Sigma\Delta x\frac{1}{d^4}\Sigma V\Delta x$$

It may be noted that in setting up the equations, any terms which remain constant throughout, such as E or numerical constants, can be grouped together outside the first summation sign. The variable terms involved in the moment of inertia should be introduced after the bending moment, or the variable terms involving the moment, have

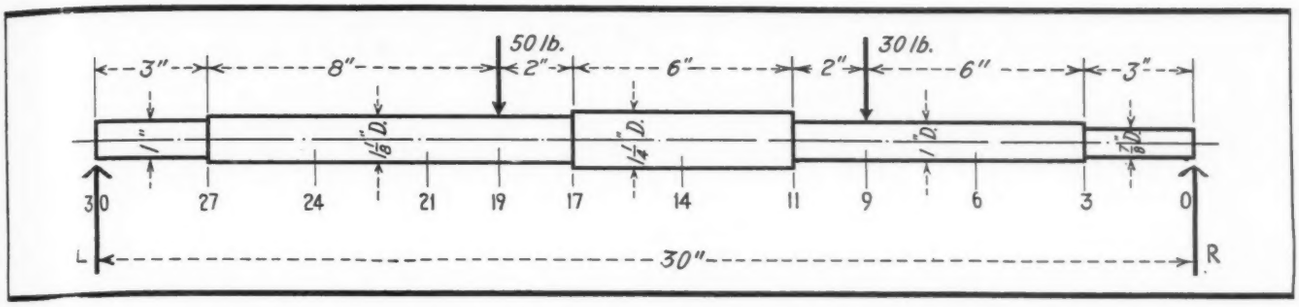


Fig. 2—The difference calculus method of finding deflections along this shaft is described in detail

been summed up, as the moment of inertia has no effect on the bending moment but does affect the slope and deflections.

The shaft is divided into a number of sections as before. The lengths in this case are not all the same, since the position of the loads and shaft dimensions do not permit it without using an excessive number of sections. In Table II, the values of d at the mid-sections are listed in column 2, the weight of the sections are calculated and entered in column 3 along with the magnitudes of the concentrated loads.

The reactions at the supports or bearings are determined by the principles of mechanics and the values in column 3 successively subtracted, giving the shear V at the ends of the sections in column 4. These are averaged in column 5 to get mean shear over each section. These are multiplied by Δx in column 6 and summed up in column 7, starting from the right end, although they could be summed from the left end just as well, and giving the values of bending moment M along the beam. The end values for each section are averaged in column 8 to get the bending moment at midpoints. Dividing the M by d^4 (column 10) and multiplying by Δx (column 11) gives a function of the ordinates of the M/I diagram.

Slope Deviation Method

It has been demonstrated, as in Seely's "Resistance of Materials," page 294, that "the difference in the slopes of the elastic curve at any two points is equal in magnitude to the area of the M/EI diagram between the two points." Since in this example the position of the zero slope is unknown, the values of slope cannot be obtained directly. If the values of column 11 are summed up starting at either end (in this example the right end), a function of the slope at any point will be obtained since the areas under the M/EI diagram or its equivalent are successively added. In other words, it is assumed that the slope at the reaction R is zero. This, of course, is not true, but will be corrected later. The end values of each section are averaged in column 13 to get the function of the slope at the midpoints.

It was shown further "the distance of any point A on the elastic curve, measured normal to the original position of the beam, from a tangent to the elastic curve at any other point B, is equal in magnitude to the moment of the area of the M/EI diagram between the two points about an area through A." Hence, if the values of column 13 are multiplied by Δx as in column 14 and summed up again for column 15, starting from the same end as before where the slope was assumed to be zero, successive functions of the moment of the areas of the M/EI diagram about the support R will be obtained. These functions are a measure in Fig. 3 of the distance a from a tangent to the elastic curve at R, to the elastic curve at the various points.

The line between the bearing centers is found by joining the end points of column 15 (T and R) with a straight line. The amounts for various values of x may be found mathematically by proportion (column 16) and are shown by the distance m in Fig. 3. A measure of the actual deflection y at any point is obtained by subtracting a from m in column 17. To get the actual deflection in inches, the values in column 17 are multiplied by the constant $64/\pi E$, which equals $0.678\ (10)^{-6}$ when $E = 30{,}000{,}000$. These are listed in column 18, and may be plotted to obtain intermediate values.

This method follows closely the graphical deflection method for a step shaft and any confusion in handling it may be cleared up by referring to that procedure. The method may be used for any type of beam or loading and gives quick accurate results.

As previously stated, the difference calculus method may be used whenever an integration is involved. It is impossible to give rules which will cover all types of problems but the general procedure is the same as outlined in the above cases. After the general method of attack has been determined for a given type of problem it may be used regardless of the manner in which the functions vary for particular cases.

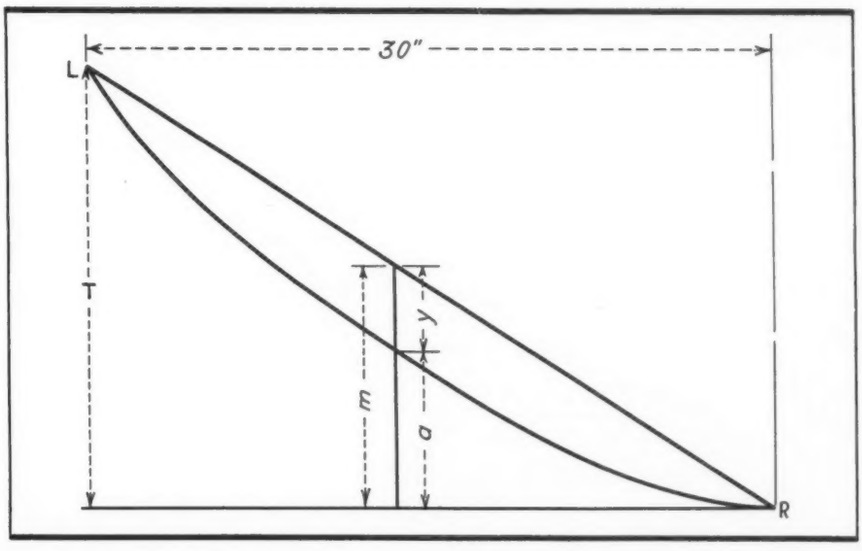


Fig. 3—Successive functions of the moment of the areas of the M/EI diagram about the support R (Fig. 2) are a measure of the distance a from tangent to the elastic curve at various points

PATENT PROCEDURE

Facilities Of The U.S. Patent Office

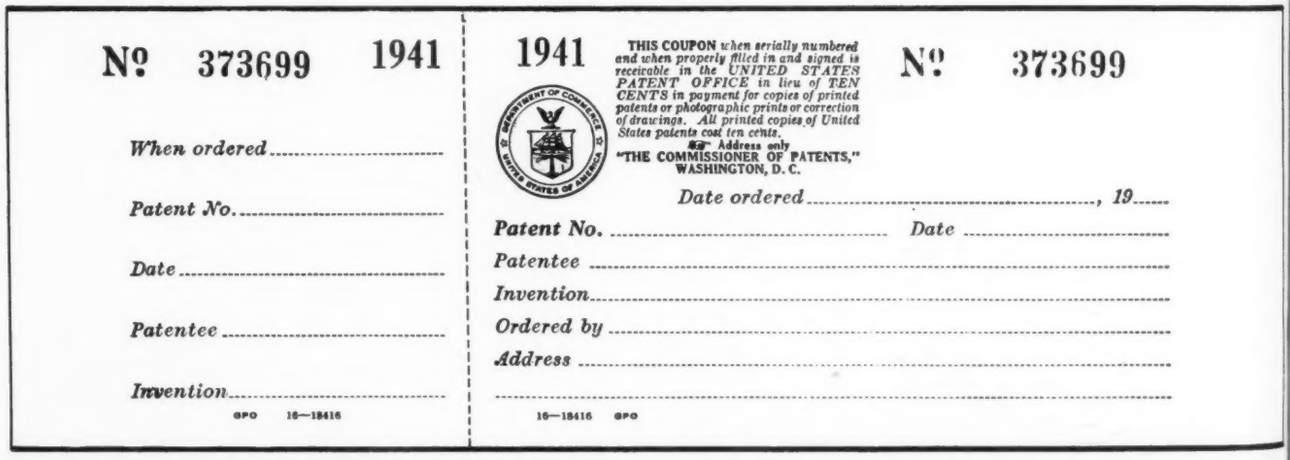
MILES HENNINGER
Patent Department, Allis-Chalmers Manufacturing Company

THE PATENT OFFICE organization is relatively simple in view of the range of work done. The Office is under the direction of a Commissioner, appointed by the President and, at present, three assistant commissioners who are also appointed. Suits involving the Commissioner in his official capacity are defended by a solicitor who also passes on general legal questions aided by two law examiners. The Office has an excellent reference library, a manuscript division, a drafting division, an assignment division and the docket division under the supervision of a chief clerk. Only the latter three divisions are directly concerned with the examination of applications and the issuance of patents.

Let us consider now the path of an inventor with an invention, who desires to find his own way into and through the Patent Office. The first step is to obtain a "Manual of Classification of Patents," issued by the Publications Division by way of the Government Printing Office. The manual is loose leaf, and insert sheets are issued to purchasers for a limited time to keep it up to date. The Publications Division can also supply pamphlets defining the classes and sub-classes indexed in the manual. The definition bulletins are issued semi-annually and now number 80. Only those bulletins defining the classes in which the inventor is interested need be obtained. Free pamphlets entitled "General Information Concerning Patents," "Patent Laws" and "Rules of Practice in the United States Patent Office" are to be had. The first one is desirable and the latter two are necessary if applications are to be prosecuted. The Publications Division also compiles the *Official Gazette* obtainable from the Government Printing Office, and can supply printed copies of photostats of patents, the annual indexes and lists of patents classified in any class desired. One volume of the index contains lists of patentees, of design patentees, of inventions and of design inventions, and the other volume contains lists of trademark applicants, of trademark registrants, a classified list of trademarks registered and a list of labels registered.

The inventor now goes to the Financial Division where he purchases coupons to be used in ordering copies of pertinent patents found. Fig. 1 shows a coupon and stub and indicates the information required to identify a patent when a copy is ordered. The Financial Division is also the receiver for all payments to the Patent Office and does all of the accounting work.

Our inventor now goes to the Search Room where he finds the stacks containing the U. S. patents classified as shown in the manual. The well-known, discouraging experience of wasting time and materials on a development already known in prior patents, can be avoided only by a search before the work is started. Inspection of the manual and the definition bulletins will indicate the field to be searched and the "search card" at the beginning of each bundle of patents will refer to other classes which should be considered. If the invention falls into only a few sub-classes, the inventor will be well advised to order all patents in such sub-classes for his consideration at leisure. A letter to the attention of the Chief Clerk will obtain the approximate number of patents in any given subclass, which may then be purchased as a subclass. Purchase of a complete sub-class or two may avoid the charges of a professional searcher or may save a trip to Washington. If the invention might be found in any one of many sub-classes, a careful search in the Patent Office search room, starting with the most likely classification and following the search card notes, is necessary. When a search is to include foreign patents, it is necessary to consult either the classified or numerically bound foreign patents in the library or to make a search, with the examiner's permission, in the classified foreign patents to be found in the examining divisions. Some countries have published only incomplete sets of patents, or abridgements or lists. However, whatever is available to the examiner is also available to the public. Before attempting to search foreign patents,



№ 373699 1941

When ordered .....

Patent No. .....

Date .....

Patentee .....

Invention .....

GPO 16—18416

1941 № 373699

THIS COUPON *when serially numbered and when properly filled in and signed is receivable in the UNITED STATES PATENT OFFICE in lieu of TEN CENTS in payment for copies of printed patents or photographic prints or correction of drawings. All printed copies of United States patents cost ten cents.*

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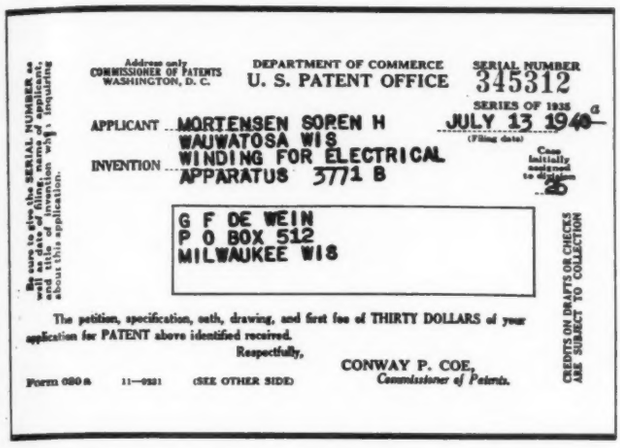
Fig. 1—This standard coupon will carry all needed information to obtain a copy of a patent and will pay for it as well



Address only COMMISSIONER OF PATENTS WASHINGTON, D. C.

DEPARTMENT OF COMMERCE
U. S. PATENT OFFICE

SERIAL NUMBER 345312

SERIES OF 1935

APPLICANT MORTENSEN SOREN H
WAUWATOSA WIS

INVENTION WINDING FOR ELECTRICAL
APPARATUS 3771 B

Case initially assigned to division 26

Be sure to give the SERIAL NUMBER as well as date of filing, name of applicant, and title of invention when inquiring about this application.

G F DE WEIN
P O BOX 512
MILWAUKEE WIS

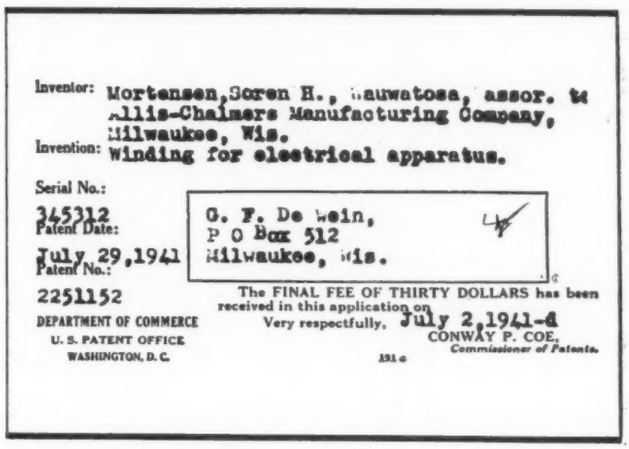
CREDITS ON DRAFTS OR CHECKS ARE SUBJECT TO COLLECTION

The petition, specification, oath, drawing, and first fee of THIRTY DOLLARS of your application for PATENT above identified received.

Respectfully,
CONWAY P. COE,
Commissioner of Patents.

Form 030 a 11—9321 (SEE OTHER SIDE)

Fig. 2—The sample filing receipt contains the newly assigned serial number of the application



Inventor: Mortensen, Soren H., Wauwatosa, assor. to Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

Invention: Winding for electrical apparatus.

Serial No.: 345312

Patent Date: July 29, 1941

Patent No.: 2251152

G. F. De Wein,
P O Box 512
Milwaukee, Wis.

The FINAL FEE OF THIRTY DOLLARS has been received in this application on July 2, 1941-d

Very respectfully,
CONWAY P. COE,
Commissioner of Patents.

DEPARTMENT OF COMMERCE
U. S. PATENT OFFICE
WASHINGTON, D. C.

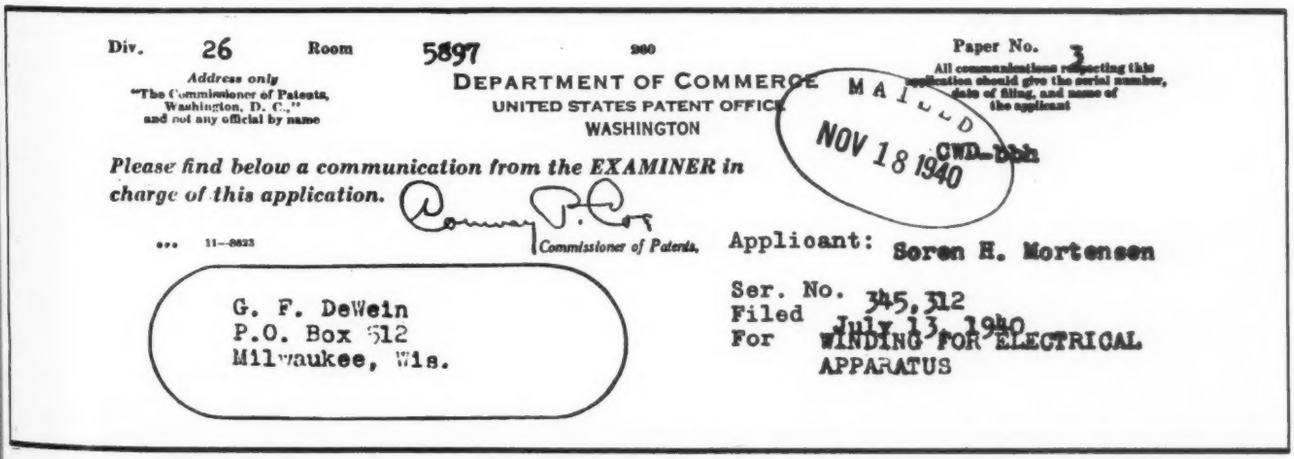
Fig. 3—This final receipt carries the patent number and date of issuance of the patent to be issued

reference should be made to the "Manual of Foreign Patents," by Belknap Severance, published in 1935 by the Patent Office Society. A search in the other publications in the library is guided by the usual library index.

Assuming that no patents or other publications showing the invention have been found, preparation of the application is next in order. The preparation of the drawing, writing of the specification and formulating of the claims are sufficiently difficult to justify later separate treatment. The complete application plus a check or money order for the filing fee ($30, plus $1 for each claim in excess of 20) is mailed the Patent Office and is received in the Mail and Files Division where a record is made of its receipt and the date of receipt is stamped on all of the papers.

The application is sent to the Application Division where it is examined to determine that it is complete and apparently in order. If some of the application papers are missing or incomplete, the applicant is so advised, the papers are held for six months and then sent to the abandoned files and the filing fee is returned to the applicant. If the application is complete, the filing fee is detached and sent to the Financial Division. A more complete record of the data relating to the application is made, a serial number is assigned to the application and a receipt for the application is sent to the applicant. Fig. 2 shows the filing receipt for the application resulting in patent 2,251,152 to S. H. Mortensen on July 29, 1941. The Application Division makes a tentative classification of the application which determines the examining division to which the application is initially sent. The drawings are sent to the Drafting Division, where they are considered for compliance with Patent Office rules and the ordinary drafting conventions. If the drawing is informal but sufficient for examination of the application, it is so marked and the filing receipt bears such notation. If the drawing is not adequate for examination of the application, the application is incomplete and a letter so advising the applicant is sent, but no filing receipt is issued.

Assuming that the application is complete and in order, the application is now sent to the Examining Division and placed in the hands of the particular examiner by whom the application is to be considered, both as to its form and its novelty, utility and patentability. The examiner first determines whether or not the application should be examined in his division. If the tentative classification is not correct, the examiner confers with the examiner who might also handle the application and, in case of failure of the two examiners to agree, the application is considered in the Classification Division for a final decision on this point. The examiner then considers the application to determine that it meets the statutes and rules as to form. Major defects in form result in an office action (see Fig. 4 showing the heading on each office action) without any action on the merits of the application, whereas minor formal defects are merely noted and made part of an action on the merits of the application. The examiner's



Div. 26 Room 5897

Paper No. 3

All communications respecting this application should give the serial number, date of filing, and name of the applicant

Address only "The Commissioner of Patents, Washington, D. C." and not any official by name

DEPARTMENT OF COMMERCE
UNITED STATES PATENT OFFICE
WASHINGTON

MAILED NOV 18 1940 CWD-Dbh

Please find below a communication from the EXAMINER in charge of this application.

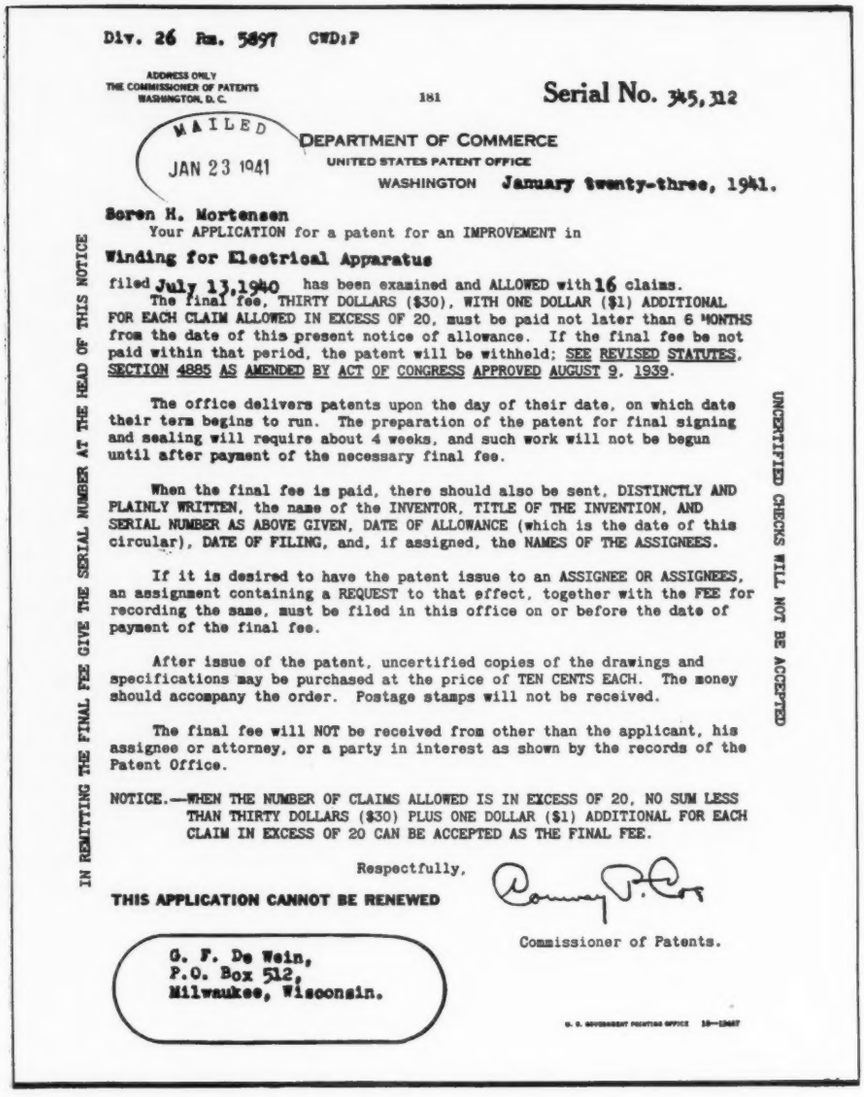
Conway P. Coe
Commissioner of Patents.

Applicant: Soren H. Mortensen

Ser. No. 345,312
Filed July 13, 1940
For WINDING FOR ELECTRICAL APPARATUS

G. F. DeWein
P.O. Box 512
Milwaukee, Wis.

Fig. 4—A notice with this type of heading indicates an office action concerning a major defect in the application



Div. 26 Rm. 5897 CWD:P

ADDRESS ONLY
THE COMMISSIONER OF PATENTS
WASHINGTON, D. C.

181 **Serial No. 345,312**

MAILED
JAN 23 1941

DEPARTMENT OF COMMERCE
UNITED STATES PATENT OFFICE
WASHINGTON **January twenty-three, 1941.**

Soren H. Mortensen
Your APPLICATION for a patent for an IMPROVEMENT in

Winding for Electrical Apparatus

filed **July 13,1940** has been examined and ALLOWED with **16** claims.

The final fee, THIRTY DOLLARS ($30), WITH ONE DOLLAR ($1) ADDITIONAL FOR EACH CLAIM ALLOWED IN EXCESS OF 20, must be paid not later than 6 MONTHS from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld; SEE REVISED STATUTES, SECTION 4885 AS AMENDED BY ACT OF CONGRESS APPROVED AUGUST 9, 1939.

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about 4 weeks, and such work will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be sent, DISTINCTLY AND PLAINLY WRITTEN, the name of the INVENTOR, TITLE OF THE INVENTION, AND SERIAL NUMBER AS ABOVE GIVEN, DATE OF ALLOWANCE (which is the date of this circular), DATE OF FILING, and, if assigned, the NAMES OF THE ASSIGNEES.

If it is desired to have the patent issue to an ASSIGNEE OR ASSIGNEES, an assignment containing a REQUEST to that effect, together with the FEE for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of TEN CENTS EACH. The money should accompany the order. Postage stamps will not be received.

The final fee will NOT be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

NOTICE.—WHEN THE NUMBER OF CLAIMS ALLOWED IS IN EXCESS OF 20, NO SUM LESS THAN THIRTY DOLLARS ($30) PLUS ONE DOLLAR ($1) ADDITIONAL FOR EACH CLAIM IN EXCESS OF 20 CAN BE ACCEPTED AS THE FINAL FEE.

Respectfully,

THIS APPLICATION CANNOT BE RENEWED

Commissioner of Patents.

G. F. De Wein,
P.O. Box 512,
Milwaukee, Wisconsin.

IN REMITTING THE FINAL FEE GIVE THE SERIAL NUMBER AT THE HEAD OF THIS NOTICE

UNCERTIFIED CHECKS WILL NOT BE ACCEPTED

Fig. 5—The notice of allowance indicates that all difficulties have been cleared up and that only payment of the final fee is needed to obtain the patent

consideration of and actions on the merits, i. e., the novelty, utility and patentability, of an application and the applicant's responses are worthy of separate and detailed consideration.

A board of supervisory examiners constantly oversees the work of the examining divisions, considers some petitions and also does general administrative work.

If the examiner and the applicant cannot agree in their interpretations of the bearing of both the statute and case law on the application, the applicant may appeal to the Commissioner or to a Board of Appeals made up of nine examiners-in-chief sitting in groups of three. Questions as to form or procedure go to the Commissioner and all questions relating to the merits of the application go the Board. From the Commissioner, a further appeal may be taken to the Court of Customs and Patent Appeals or to the Federal District Court (for the eastern district of Maryland), but appeals from the Board may be taken only to the Court of Customs and Patent Appeals.

If an application is found to interfere with another application or with an issued patent, i. e., if the allowable claims in the application are readable on another application filed within (approximately) six months of the first application now found allowable, the examiner suggests that each of the applicants copy the claims having subject matter common to both and institutes a contest between the applicants. The contest is called an interference and its purpose is to determine who is actually the first inventor of the subject matter of the claims. After the examiner has declared the interference, the interfering applications are sent to the Docket Division and the applications are thence forwarded into the hands of the Interference Examiners. An interference being a contest between two or more parties, various pleadings are required to fix the questions in issue and to establish the positions of the parties, evidence is taken and presented and the case is heard and argued just as in any other legal contest. A decision is rendered by the examiners, sitting in boards of three, and is appealable to the Board of Appeals and from there to the Court of Customs and Patent Appeals. Few persons are competent to carry through an interference and few persons, even including patent attorneys, are really skilled in the practice. A later article will give the general practice in interferences but will not go into the detail necessary for prosecution of an interference.

After the objections of the Examining Division as to form have been met or overcome, the claims have been so written as to define and distinguish accurately the instant invention from all other prior references, and any question of first inventorship has been settled by termination of an interference, the application is allowed and a notice of allowance is forwarded to the applicant. Fig. 5 shows the notice of allowance in the application resulting in patent 2,251,152. After issue of the notice of allowance, the application is sent to the Issue and Gazette Division, where the application remains until the final fee is paid and from which the application is sent to the Government Printing Office.

If the patent to issue has been assigned to a purchaser and is to bear notice of such assignment on the printed patent and copies thereof, it is necessary that the assignment be recorded in the Assignment Division before the application goes to the printer. It is good practice to send the assignment with the fee ($3) for recording at the time the final fee is paid.

Design and trademark applications follow much the same course in the Patent Office as outlined for inventions, but are handled in separate divisions and will be separately considered. Copyrights and prints and labels are handled by the Register of Copyright and will be separately considered.

If the inventor has occasion to consult the prosecution file of a patent, such files are available in the attorneys' and record room and photostat copies can be ordered from the Manuscript Division.

Further details regarding Patent Office procedure may be obtained from the "Manual of Patent Office Procedure," by C. L. Wolcott, 8th edition, published by the Patent Office Society.

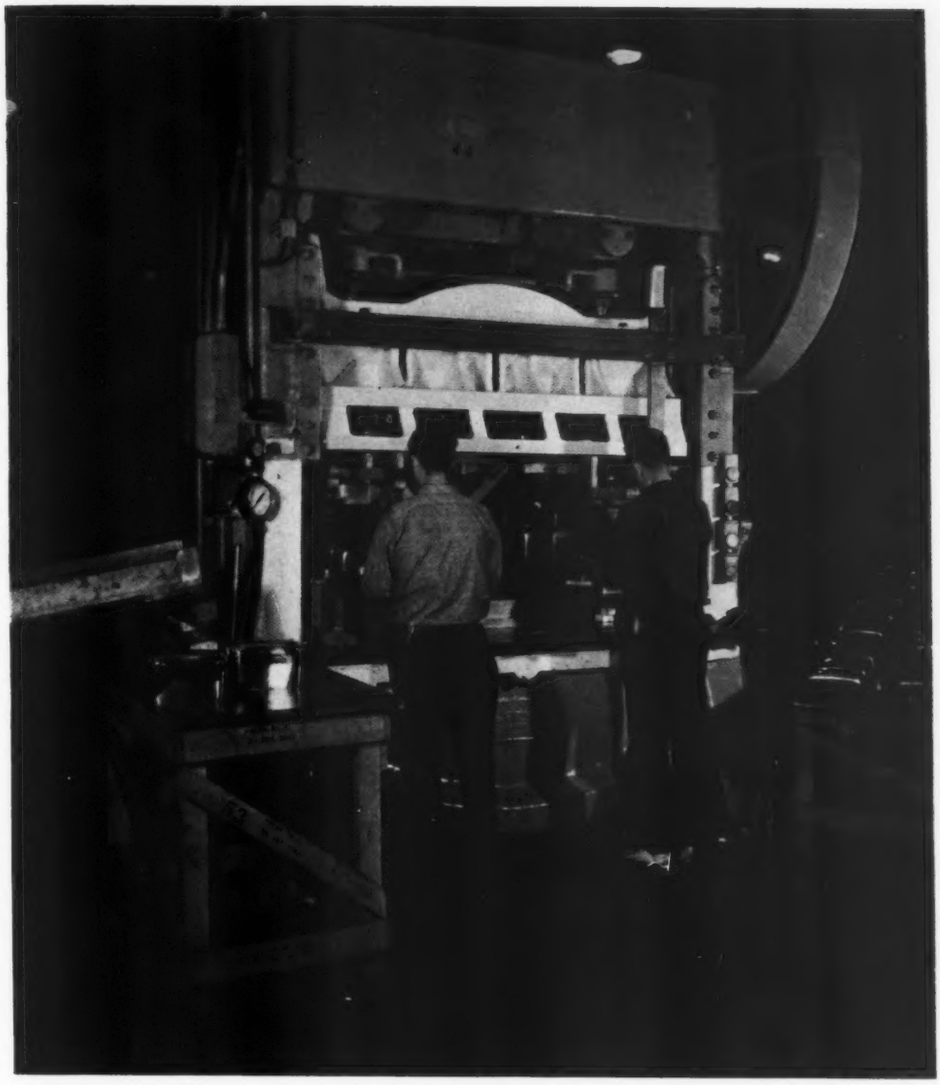


Fig. 1—Operators can see better and work faster since working areas were painted light buff

COLOR FOR EFFICIENCY

MATT DENNING
E. I. du Pont de Nemours Company

ARTHUR A. BRAINERD
Philadelphia Electric Company

TWELVE YEARS AGO workers in a shoe factory complained of headaches and blind spots. An executive of the company, while watching a man at work on a black shoe in a black-painted machine, suddenly noticed that there was no contrast between shoe and machine. The dark surfaces made seeing difficult. Acting upon impulse, he told the operator to select a pleasant color from the paint shop and repaint his machine.

The shop soon looked like a kaleidoscope as other workers followed suit, but with the switch to lighter colored paints which gave better contrast between shoe and cutting edges, the accident rate fell off 70 percent. Production increased; there was less fatigue and fewer "seconds."

The average well-lighted machine shop presents the same problem. Machines are usually painted dark green, deep gray, or black. Contrast between metal work and machine is not adequate, and the dark paints soak up much of the light directed upon them. In short, machines and work areas are too well camouflaged. The problem cannot be completely solved by piling on high-level lighting in such surroundings, but it can be reduced to that of finding the best color for the machines themselves.

Research conducted by the Philadelphia Electric Company and E. I. du Pont de Nemours & Company indicates that the most effective results are obtained by painting the base and body of a machine with a medium gray paint. and "spotlighting" the working area with a light buff.

As shown in Figs. 1, 3 and 4, light buff is painted on all areas which act as a background for the work or cutting edges except, of course, for table surfaces, ways, and other operating surfaces. The light buff should also be painted on areas from which light is

reflected onto working surfaces. Boundaries for the buff area are best determined by natural "breaks" in the machine, such as a junction of parts, or a line on a casting.

Conditions of Tests

Research was conducted with several colors of paint on a small punch press and a power shear in the repair machine shop of the Philadelphia Electric Company. These machines were selected for the test because they duplicate conditions which exist generally in machine shops. Both incandescent and mercury lighting equipment was installed. Mercury light was provided by a 450-watt low-pressure mercury tube suspended over each machine. Incandescent light for the shear was supplied by a 500-watt silvered bowl lamp in a diffuser; for the punch press by four 200-watt clear lamps in angle reflectors. Illumination in the working area was maintained at approximately 30 foot-candles.

Colors selected for the test were in general light, but some dark colors were chosen for comparison. Some tests were made with the whole machine painted the same color; others were made with the base and large background areas painted one color, and the working area "spotlighted" with a different color. Colors tested on the shear were: battleship gray (original color), aluminum, light green, light gray, light gray with dark green background, light gray with medium gray background, and light buff with medium gray background.

Colors selected for the punch press were: battleship gray (original color), yellow, light blue, light buff, medium gray and light gray background, and light buff with medium gray background.

Three tyes of tests were made: measurement of light reflecting characteristics; effect of different colors upon production; and a questionnaire to determine psychological factors. In the reflectance measurements, readings were taken of light falling on the work surface and of light reflected in order to obtain accurate photometric records of each color tested. Important surfaces of each machine were divided into zones, each with an area of 1 sq. ft. Readings in each zone were taken with the Macbeth illuminator. Illumination was then measured in foot-candles of light falling on the machine surface. Brightness (a function of illumination and the reflection factor of the surface) was measured in foot-candles of light reflected back from the machine.

Time-study records were made of three simple jobs performed on the shear. The jobs were performed by an experienced operator and the times were recorded under both mercury and incandescent lights for each color.

The psychological effect of the various colors upon workers was determined by handing out questionnaires to each of a group of 15 men, including 2 foremen. Questions asked were: (1) Is

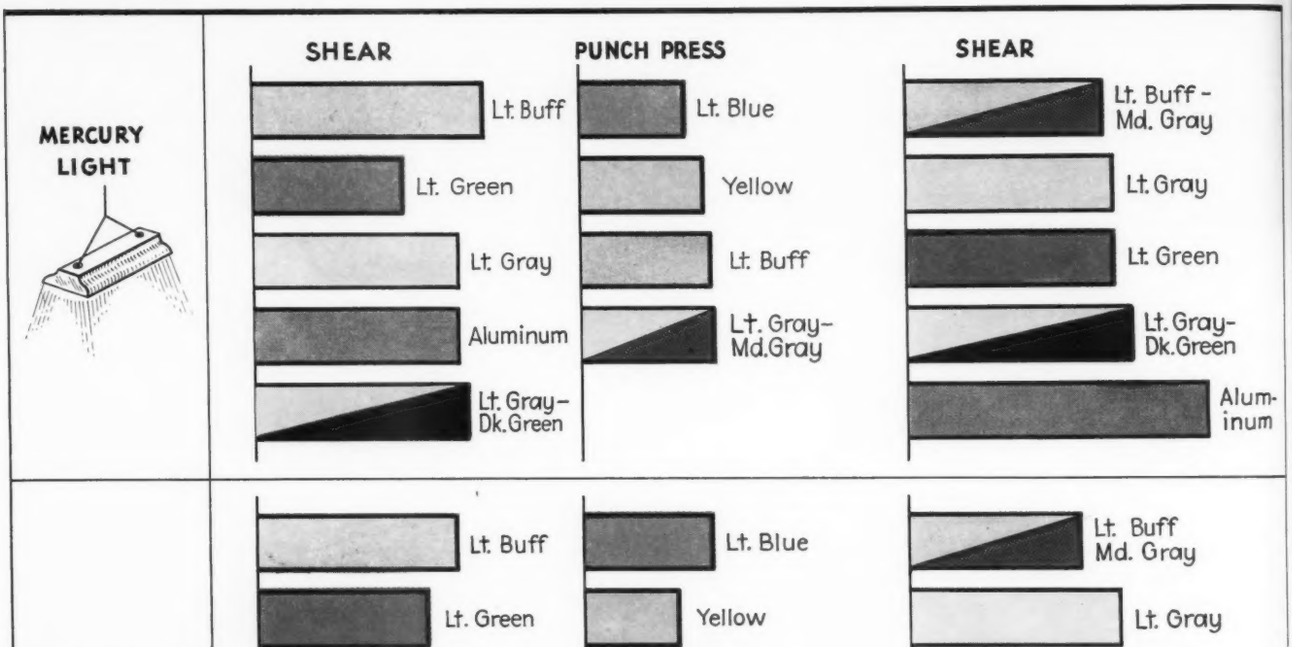


Fig. 2—Results of light reflectance and time study tests of machine tools painted various colors

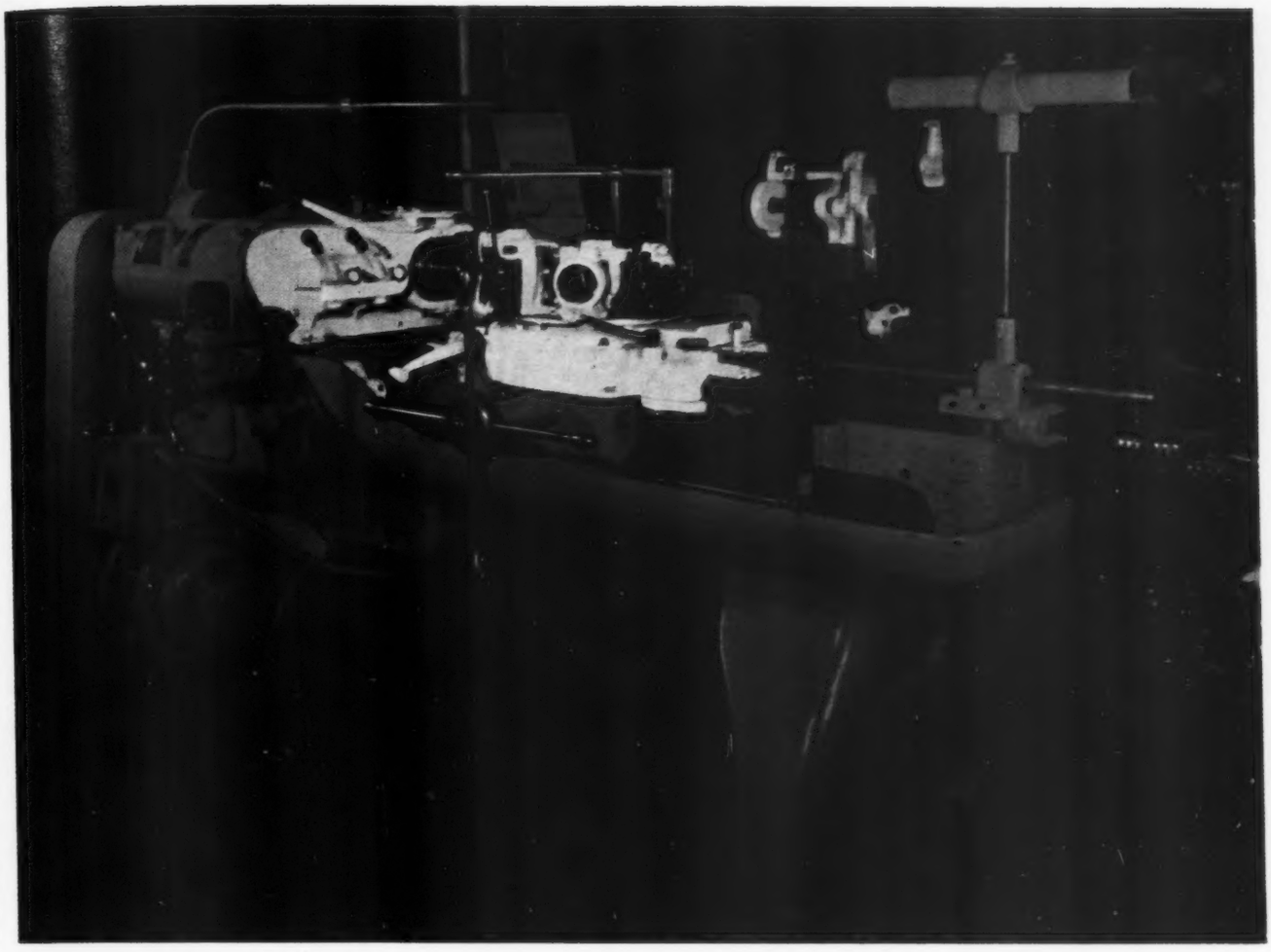


Fig. 3—Finish on turret lathe is slightly oil-streaked as a result of average hasty clean-up and is chipped where heavy tools or work have been dropped, but effect of light-buff-medium gray combination is not spoiled after 6 months of actual service

paint more or less tiring than original? (2) Can you see better than with original? (3) Can you work faster than with original? (4) Is it easier to do better work than with original? (5) Do you need more light? (6) Do you think it is safer than before?

Results of the Tests

Assuming that maximum light reflection is essential to best seeing, the most important study was the relative brightness of various parts of the machine adjacent to the working area. Fig. 2(A) shows the results of these measurements. Each color is reproduced in the bars of the chart. General conclusions are qualitative rather than quantitative. Of the colors tested on the shear, light gray and aluminum are so nearly the same under mercury light that there is little choice. Under incandescent lights, however, aluminum gives not nearly as consistent a performance. In either case, the reflecting properties of light green are high enough to warrant serious consideration. Light buff is definitely better than any of the other colors.

All the colors studied on the punch press are nearly the same under mercury light. Under incandescent light, yellow is not quite as good a performer. Light buff is the best color.

The apparent discrepancy in the reflections that have been secured on the two machines, chart Fig. 2(A) is due to the larger area of painted surface on the front of the shear which reflects more light down upon the working surfaces. The chart shows that from a light reflection standpoint there is no reason to assume that gray or aluminum is always a logical choice. Light buff gave consistently good performance.

Fig. 2(B) shows the results of the time studies on the shear. These results are surprising since they indicate that for certain specific tasks there is little to choose between light buff on medium gray and light gray or light green as far as production is concerned. Another interesting indication is the drop in speed with light gray when the bulk of the machine is painted a dark green. One explanation is the marked contrast in brightness within the range of vision.

While the results of the questionnaire are not conclusive, because the study was confined to a period of a few weeks for each color, they do indicate that lighter colored machine finishes possess definite advantages. Comparing the test colors with the original gray, 100 percent of the men said they could see better with light buff; 28.6 percent said buff was less tiring, and the remainder stated no difference in fatigue. When asked "Is it easier to do better work with light buff?" 57.2 percent replied "yes," 14.3 percent said "no," and 28.5 percent reported "no difference." The same percentages thought they could do better work with light buff, and all felt the new color made the job safer.

On the whole, aluminum was liked by the workers as well as light buff, outranking the buff paint in the "work faster" and "do better work" questions, and inferior as to better seeing and fatigue. Light gray had a high rating, but was considerably better under incandescent light than under mercury

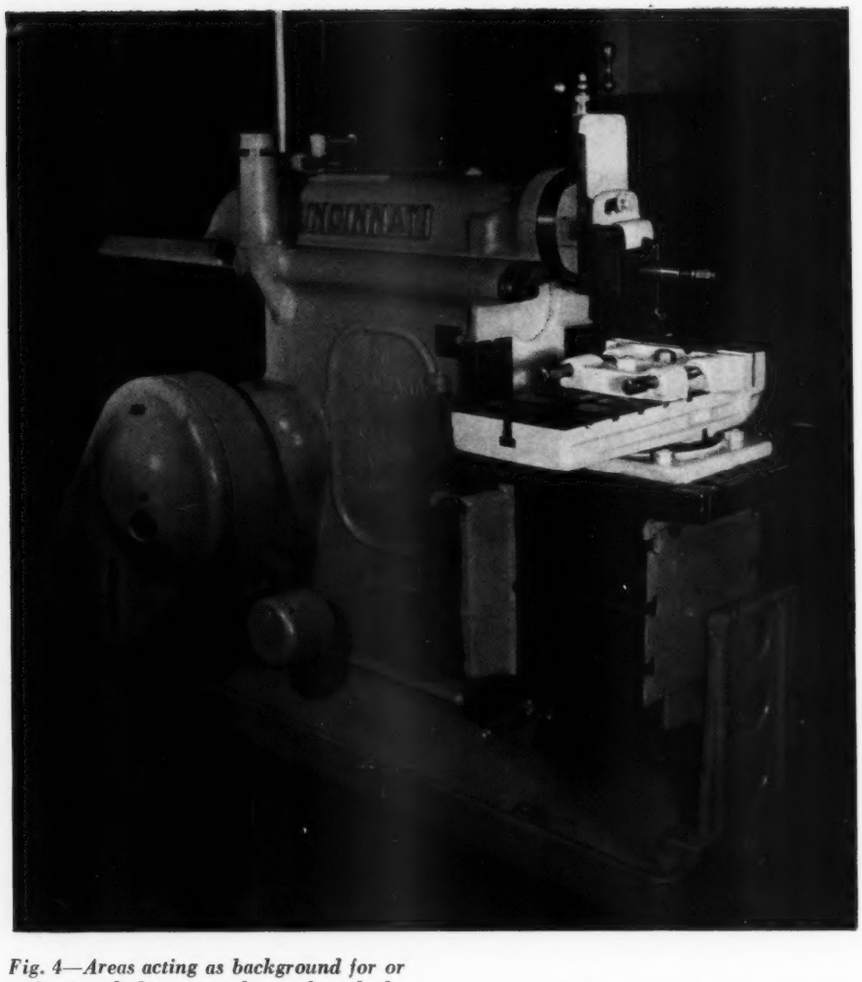


Fig. 4—Areas acting as background for or reflecting light upon the tool and the work should be painted with light buff; remainder with medium gray. Semi-gloss, oil-resistant machine paint recommended

light. Yellow was found to be tiring.

In order to reduce all three of these types of tests on the two machines to the same basis, a composite rating was worked out for each test. These ratings are compared in Table 1. This study shows a definite trend toward light buff, with light gray and aluminum standing high on the list.

What About Maintenance?

From the maintenance viewpoint, it was decided that it was not practical to paint machines entirely with light buff. Accordingly, all machines in the Philadelphia Electric Company repair shop were painted a medium gray with light buff around the working area. The purpose was to utilize the light reflectance of the lighter finish where needed most around the working areas, and still satisfy maintenance requirements of a finish that will not show dirt too readily in areas not usually kept clean. Also, it was deemed advisable not to paint the entire machine with the light buff; glare from such a large bright area in front of the worker might cause eyestrain during an 8-hr. shift. Surprisingly, the combination seems to perform better than any of the solid colors.

It is, of course, necessary to specify an oil-resistant, washable machinery paint, semi-gloss type recommended. These painted surfaces can easily be wiped off with waste or cleaned with kerosene, gasoline or safety machine cleaners.

During the two-year period of study with buff and gray machines, it has been found that the machinists are so convinced of its benefits, and the color appeals to them so much that they keep the light area clean of their own accord. Fig. 3 shows a turret lathe that has been in operation for more than six months without refinishing. The picture, reproduced from unretouched natural color film, shows the lathe about as clean as the average operator keeps it.

Research has found: (1) the soft contrasts created by the light buff-medium gray combination are easier on the eyes than abrupt changes in brightness; (2) these colors are best in reflective qualities; (3) operating time was faster and more efficient because lighter tool areas concentrated attention on the work and high-lighted danger points; and (4) workers react more favorably to buff and gray.

Table I—Composite Rating of Colors Tested*

Color of Paint	Mercury Light — Percent Rating					Incandescent Light — Percent Rating				
	Time Study	Reflected Light	Questionnaire	Average	Final Rating	Time Study	Reflected Light	Questionnaire	Average	Final Rating
Punch Press										
Yellow		92.3	8.7	50.5	51.1		64.6	10.7	37.7	37.7
Light Blue		79.3	31.2	55.3	56.0		88.0	61.6	74.8	74.8
Light Buff		97.5	100.0	98.8	100.0		100.0	100.0	100.0	100.0
Medium Gray and Light Gray		100.0	43.7	71.9	72.6		93.7	53.9	73.8	73.8
Shear										
Light Buff	100.0	100.0	100.0	100.0	100.0	100.0	92.9	100.0	97.6	100.0
Aluminum	67.1	88.4	100.0	85.2	85.2	69.1	78.6	100.0	82.6	84.6
Light Green	95.5	64.8	18.2	59.5	59.5	85.5	77.7	19.6	60.9	62.4
Light Gray	97.2	87.5	54.0	79.6	79.6	82.8	96.5	97.6	92.3	95.6
Dark Green and Light Gray	88.5	91.1	18.5	66.0	66.0	75.8	100.0	23.3	66.4	68.0

* Percent ratings for Time Study and Reflected Light were determined from test results; in each case 100 percent was assigned to the color found best, and other colors were rated in proportion. Questionnaire returns are expressed as percent of workers who noted improvement over gray in all respects. These three ratings are then averaged for each color, and the color (light buff) having the highest average rating is assigned a composite rating of 100 percent. These values are comparative values only.

PHOTO-TRACINGS

Their Use in Making Pictorial Blueprints

LESTER C. JONES
Engineer, Lockheed Aircraft Corporation

SINCE the prime purpose of making shop blueprints is that they serve as a means of conveying instructions from the engineering department to the various departments concerned with production, assembly and installation, it is obvious that it is desirable to employ every convenient and economical means that will shorten the time spent in deciphering or reading the blueprints. One means that is effective in promoting the ready interpretation of blueprints is to employ a pictorial style of presentation.

Engineers know that conventional unshaded outline drawings of parts and assemblies are not visualized with the same facility as are photographs of the same parts or assemblies. Contact photographic prints, however, for many reasons are not a satisfactory method of issuing instructions to the shop. To bridge the wide gap between line drawings and photographs, blueprint reproductions made from photo-tracings can be effectively employed.

Photo-tracings are photographic negatives produced on tracing cloth. They are negative only in regards to black and white color values, otherwise they are positive, that is, the image is not reversed in direction from left to right as it is on a conventional photographic negative.

This result is obtained by first photographing the part to obtain a negative. All illumination used to take the first exposure is then removed with the exception of the lights located under the glass upon which the part was placed. Another exposure is then made. The resultant negative will show a clear silhouette of the part on a black background. A positive film is then developed from the original negative. This film is matched with the silhouette film or "mask" and used in the enlarger to produce the negative photo tracing.

The cloth used is purchased already prepared with the sensitized coating on one side and a waterproof coating on the other. The latter is to prevent the cloth from being destroyed while in the developing baths. If there is any shrinkage at all on the tracing after developing and drying, it is negligible.

Photo-tracings combine the advantages inherent in photographs and in

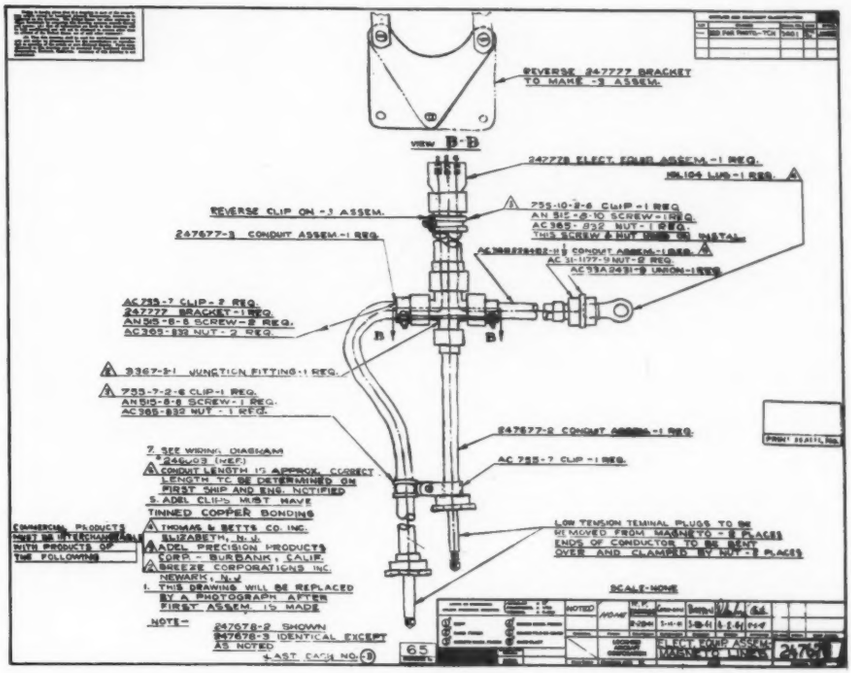

REVERSE 247727 BRACKET TO MAKE -3 ASSEM.
VIEW B-B
247728 ELECT. EQUIP ASSEM. -1 REQ.
REVERSE CLIP ON -3 ASSEM.
247677-3 CONDUIT ASSEM.-1 REQ.
AC755-7 CLIP - 2 REQ.
247727 BRACKET-1 REQ.
AN365-8-8 SCREW-2 REQ.
AC365-832 NUT - 2 REQ.
9367-21 JUNCTION FITTING-1 REQ.
755-7-2-6 CLIP-1 REQ.
AN515-8-8 SCREW-1 REQ.
AC365-832 NUT - 1 REQ.
247677-2 CONDUIT ASSEM.-1 REQ.
AC 755-7 CLIP - 1 REQ.
LOW TENSION TERMINAL PLUGS TO BE REMOVED FROM MAGNETO - 8 PLACES
ENDS OF CONDUCTOR TO BE BENT OVER AND CLAMPED BY NUT - 8 PLACES
SEE WIRING DIAGRAM 246603 (REF.)
CONDUIT LENGTH IS APPROX. CORRECT LENGTH TO BE DETERMINED ON FIRST SHIP AND ENG. NOTIFIED
ADEL CLIPS MUST HAVE TINNED COPPER BONDING
THOMAS & BETTS CO. INC. ELIZABETH, N. J.
ADEL PRECISION PRODUCTS CORP. - BURBANK, CALIF.
BREEZE CORPORATIONS INC. NEWARK, N. J.
THIS DRAWING WILL BE REPLACED BY A PHOTOGRAPH AFTER FIRST ASSEM. IS MADE
NOTE - 247678-2 SHOWN 247678-3 IDENTICAL EXCEPT AS NOTED
SCALE-NONE

Fig. 1—Sketch tracing drawn free-hand in pencil, used only for making a mockup of assembly to be photographed

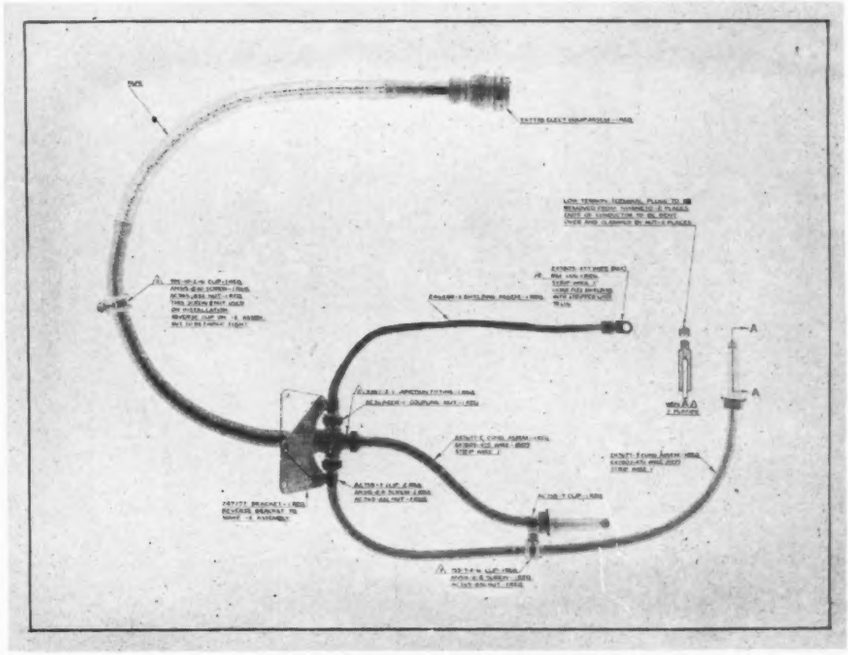


Fig. 2—Finished photo-tracing made by photographing the mockup as specified by sketch tracing shown in Fig. 1. All lettering on photo-tracing is in ink

Fig. 3—Ink should be used for all lettering and additions to photo-tracings. If pencil is used the photo portion of the tracing "burns out" on the blueprint reproduction before pencil lines can be reproduced

linen tracings. They are pictorial illustrations to which can be added informative notes and sketches, all of which can be reproduced in the form of blueprints.

A description of how photo-tracings are made use of at the Lockheed Aircraft Corporation may help other engineers to appreciate what can be done to help the men who work from blueprints. Formerly it was the duty of the manufacturing engineering department to "break down" the electrical member of what is termed "production assemblies." These "break-downs" were not engineering release drawings inasmuch as they contained nothing more than a list of the parts which made up the assembly. Today production assembly drawings are made by photographing on sensitized cloth assembled units obtained from the stockroom. The photographic negative after processing becomes a photo-tracing. The photo-tracing is completed by adding to it the call-outs from the old production assembly drawing, either by having them typed and then photographed on the tracing before processing or by adding them later with ink.

If these production assemblies have been in use for some time so that they

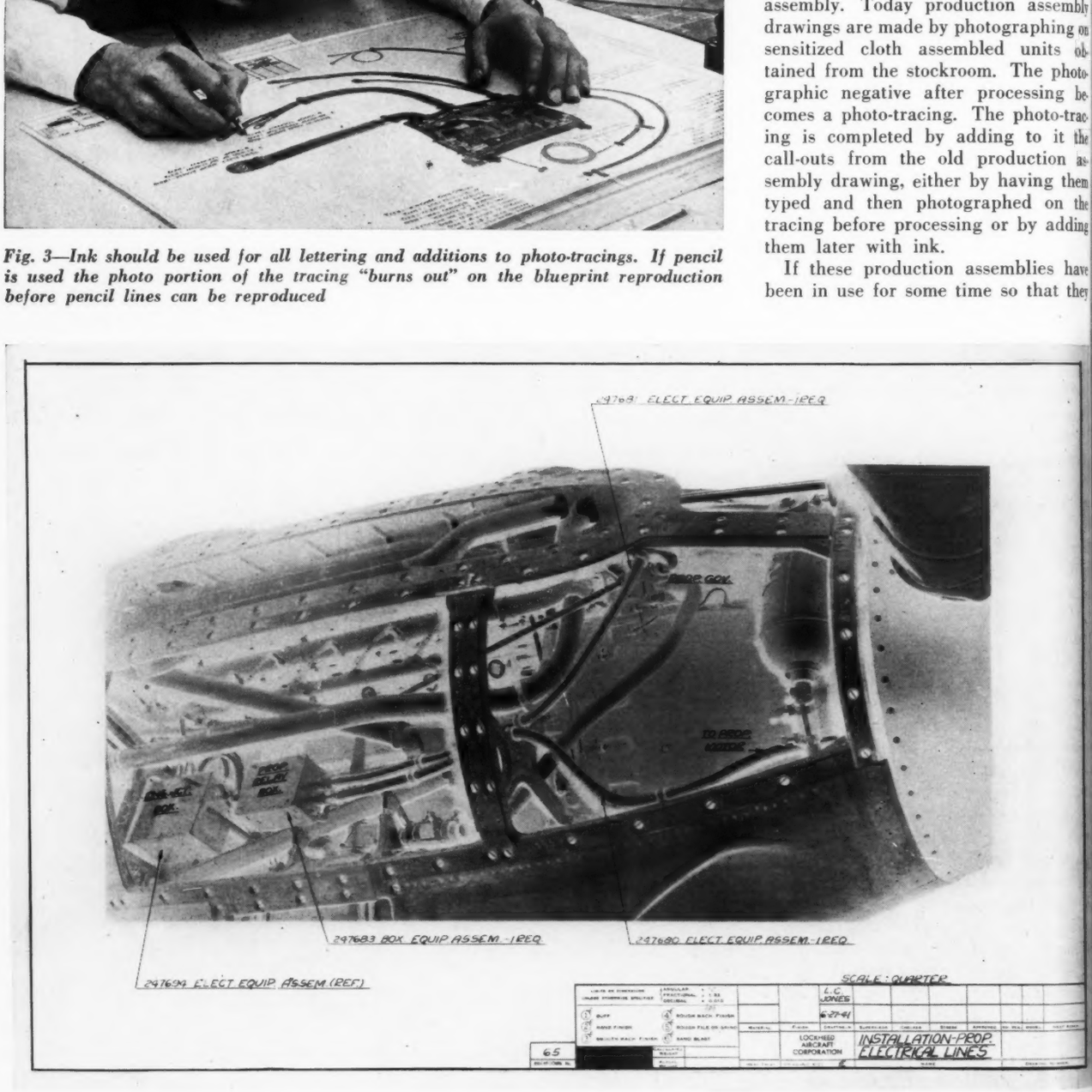


Fig. 4—Photo-tracing used for installation drawing. Note the reversed black and white color tones

have been more or less proved for accuracy and completeness, and there is no present possibility of subsequent changes in design or arrangement, prints from the photo-tracings are released at once through the regular channels.

Procedure With New Designs

It is not quite so simple to produce an accurate tracing for a new design, yet the procedure is about the same as that taken in making a photo-tracing of an old, approved design. Instead of a "production assembly drawing" a "sketch-tracing" is made like that shown in Fig. 1, which is nothing more than a hand sketch of the assemblies which have been previously designed, checked and released through the proper channels. With the aid of this sketch, a mockup of the assembly is made and proved. The mockup is then photographed on sensitized cloth and processed to obtain the photo-tracing. After the call-outs are added in ink by a draftsman, as shown in Fig. 2, the new photo-tracing is released to take the place of the sketch tracing.

Through much experimenting the author has learned that in the blueprinting process the exposure needed to bring out penciled lettering from photo-tracings is so much greater than that required for the photograph portion of the tracing, that the picture itself is "burned out" on the blueprint. Since the major purpose of using photo-tracings is to supply the shop with a clear pictorial view, a clean sharp reproduction of the photograph is important, therefore, the use of pencil for lettering or additions is not satisfactory. The ideal blueprint is produced when ink lettering is used on the photo-tracing. Ink on this type of tracing can be easily removed if need be, either with an eraser, scraper or water.

The use of photo-tracings is recommended wherever a true reproduction is wanted of a part or parts of assemblies that cannot be readily drawn by the draftsman such as plumbing, controls, landing gear or furnishings.

Installation Drawings

Another type of drawing, similar to production assembly drawings, that can utilize the photo-tracing process to advantage is the "installation drawing." Frequently in the conventional type of drawing it is next to impossible to show some intricate arrangements clearly enough to remove all doubt in the minds of the men who do the installing in the shop. A true picture or photograph, like those shown in Figs. 4 and 5, of the installation helps considerably. At the Lockheed plant, views showing the relative position of assemblies to other members of the airplane are used in addition to regular drawings. The views of the actual installation can be reproduced with the installation on the same tracing, so that the men in the shop can be supplied with a true reproduction of the former installation plus actual photographs of difficult installations. If the installation drawing is drawn quarter-scale, the photographs can also be made quarter-scale. This is also true, of course, for half or full-scale views.

Designers while considering the advantages that accrue through the use of photo-tracings should also keep in mind the economic factors involved. It is not recommended that the process be used indiscriminately, but only at times when its advantages as an aid to production have been definitely ascertained by the departments affected and the use of the process justified on the basis of time and cost involved.

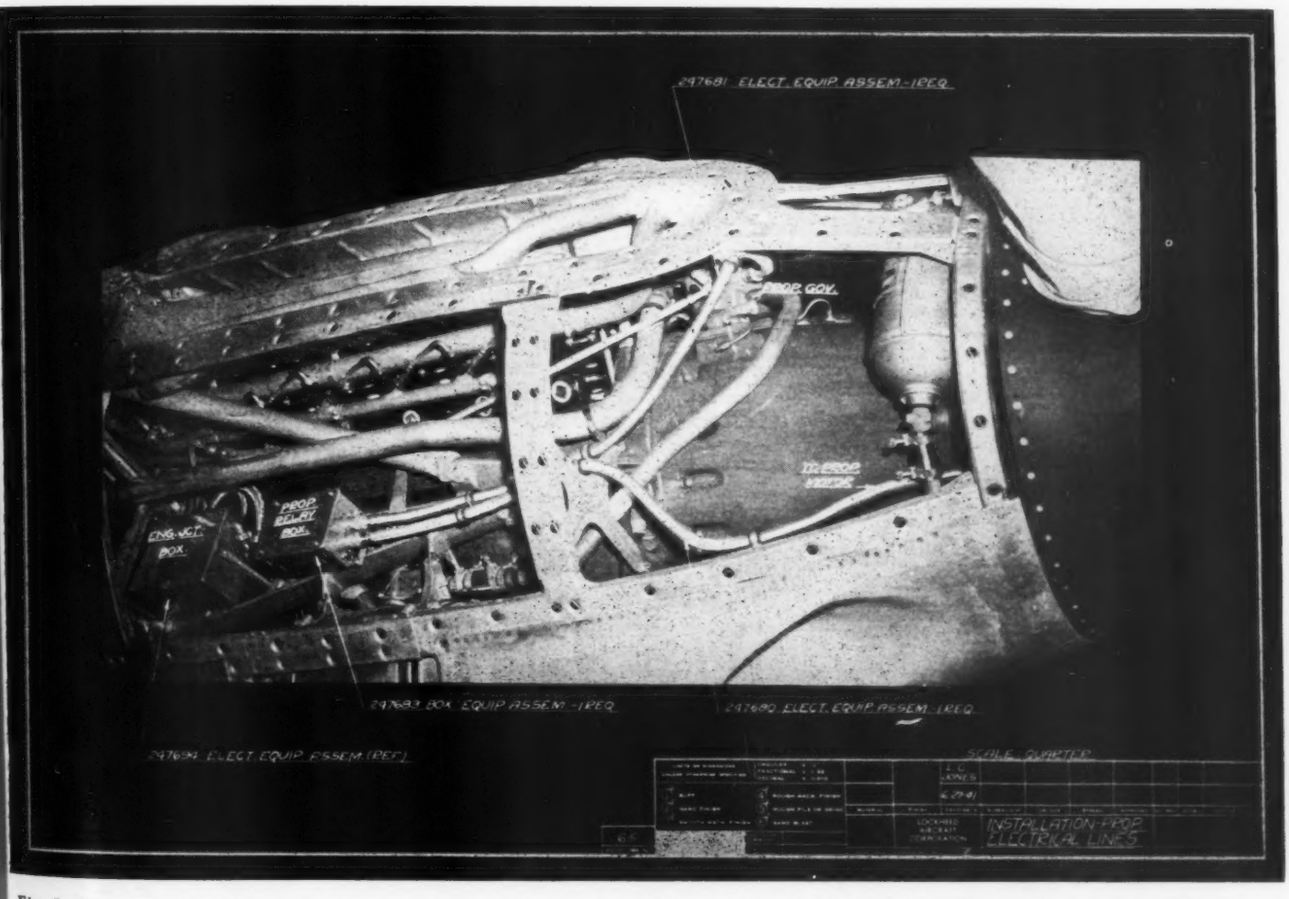


Fig. 5—Blueprint installation drawing made from photo-tracing shown in Fig. 4. Note the positive black and white color tones

ELECTRICAL TIMING

TIMING DEVICES have been classified into several divisions distinguished largely by the length of the time interval, the number of timed operations in sequence, and whether or not they are designed for repetition or cycle operation. The most popular timing devices depend upon clock-operated cams for tripping electrical contacts and considerable ingenuity is shown in variations of the method of making and operating cams.

Not all timing devices operate mechanically, it should be pointed out, although those that depend entirely upon electrical circuit characteristics are beyond the scope of this group. Their time interval is usually comparatively short. The devices shown here take advantage of cams and related devices, period of vibration of a released solenoid contact arm, a pendulum-time escapement, dashpot delay, rate of flow of mercury through a small orifice, and expansion time of an electrically heated wire.

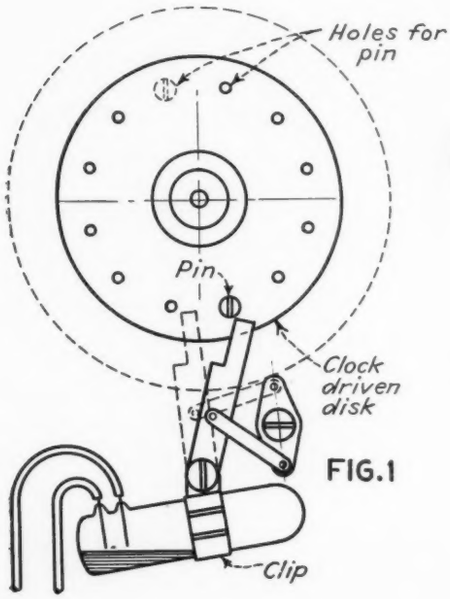


FIG.1

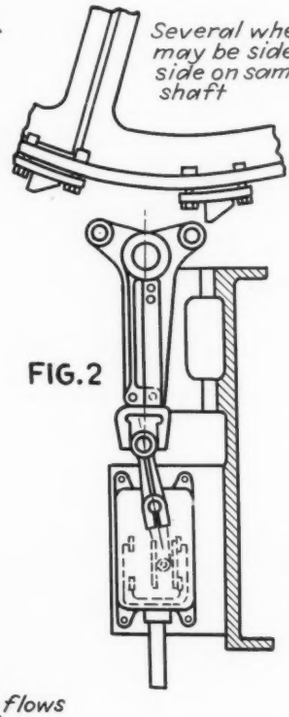


FIG.2

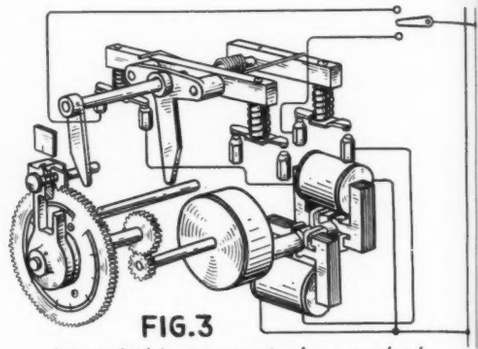


FIG.3

Adjustable spaced pins on clock-driven wheel control timing of contacts

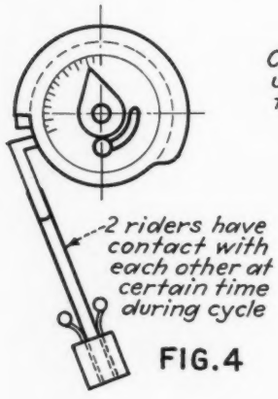


FIG.4

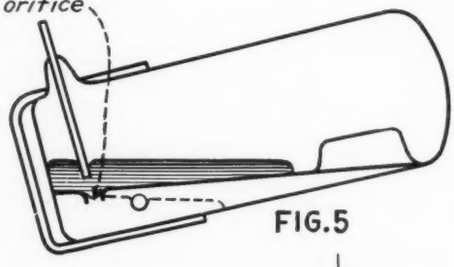


FIG.5

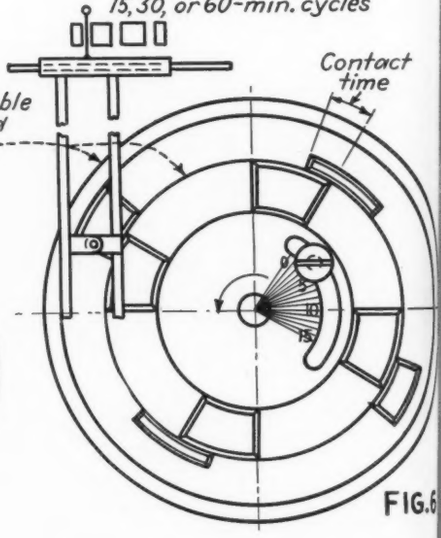
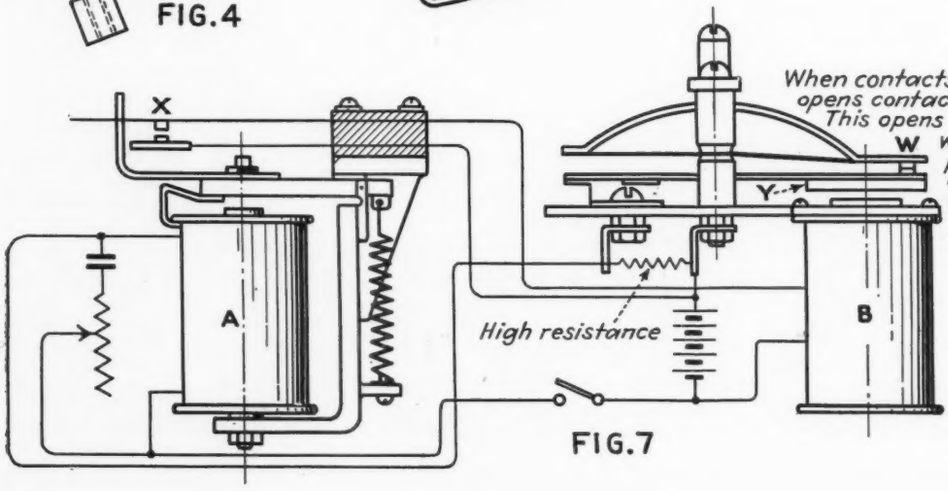


FIG.6


X
A
B
W
Y
When contacts W part, A circuit opens contacts X
This opens B circuit, releases Y which vibrates and prevents working contact through W for desired period
High resistance
FIG.7

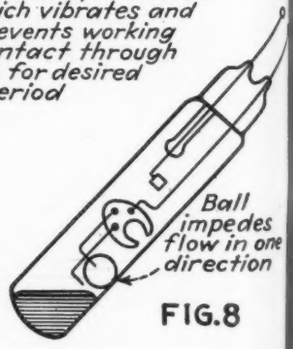


FIG.8

DEVICES — *Their Operating Principles*

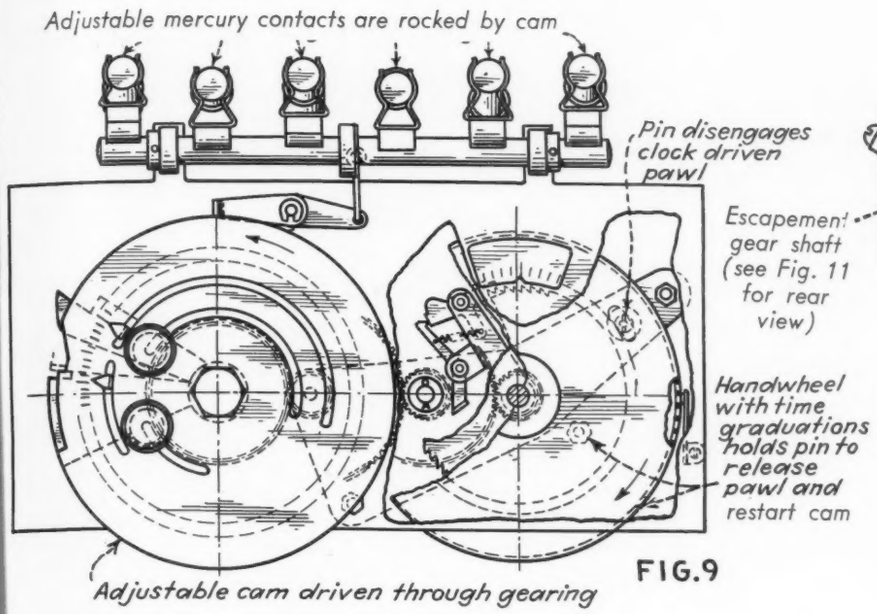

Adjustable mercury contacts are rocked by cam
Pin disengages clock driven pawl
Escapement gear shaft (see Fig. 11 for rear view)
Handwheel with time graduations holds pin to release pawl and restart cam
Adjustable cam driven through gearing

FIG. 9

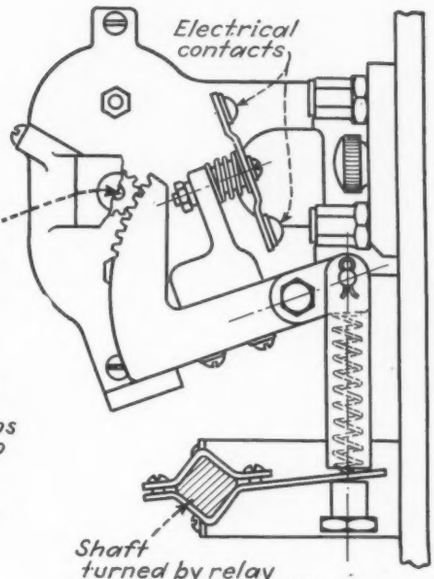


FIG. 10

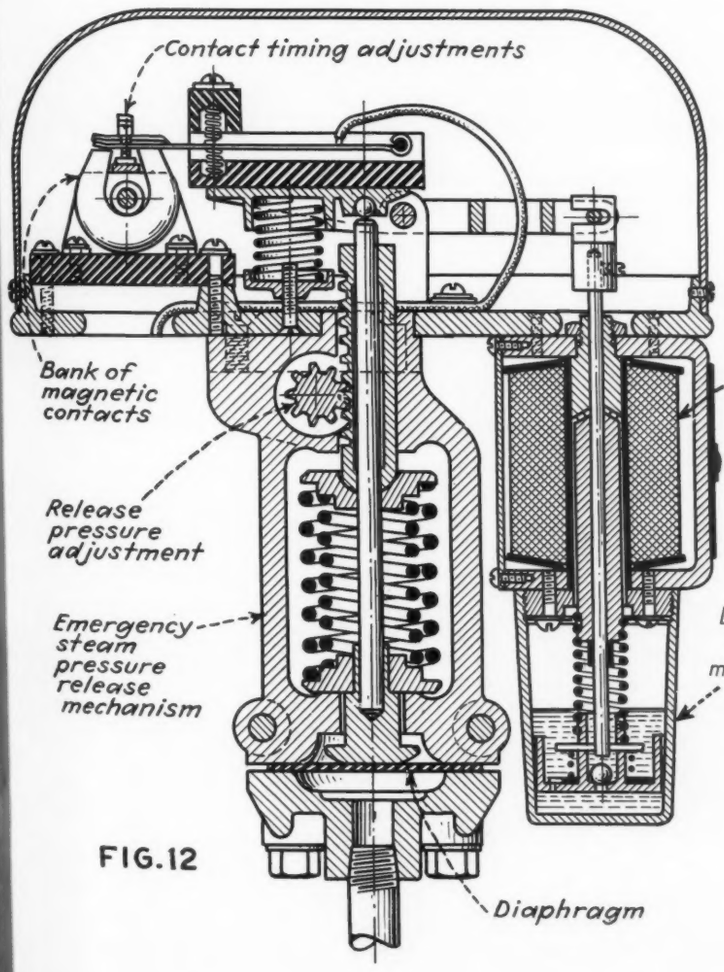


FIG. 12

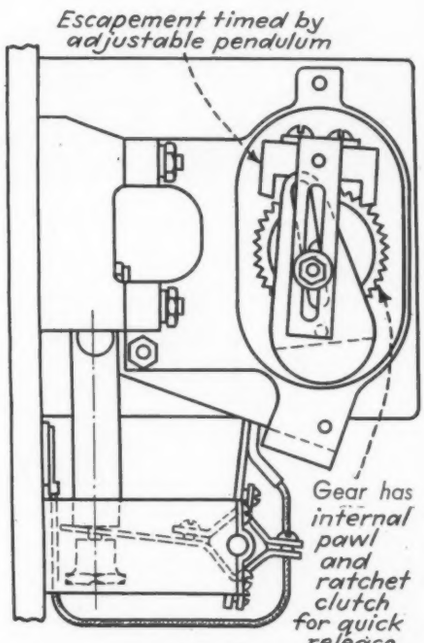


FIG. 11

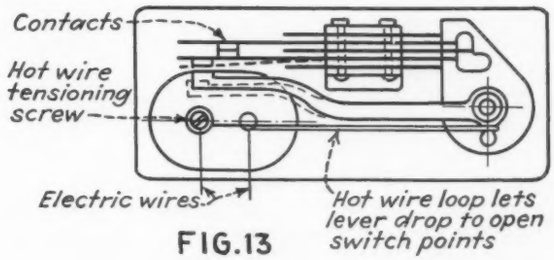
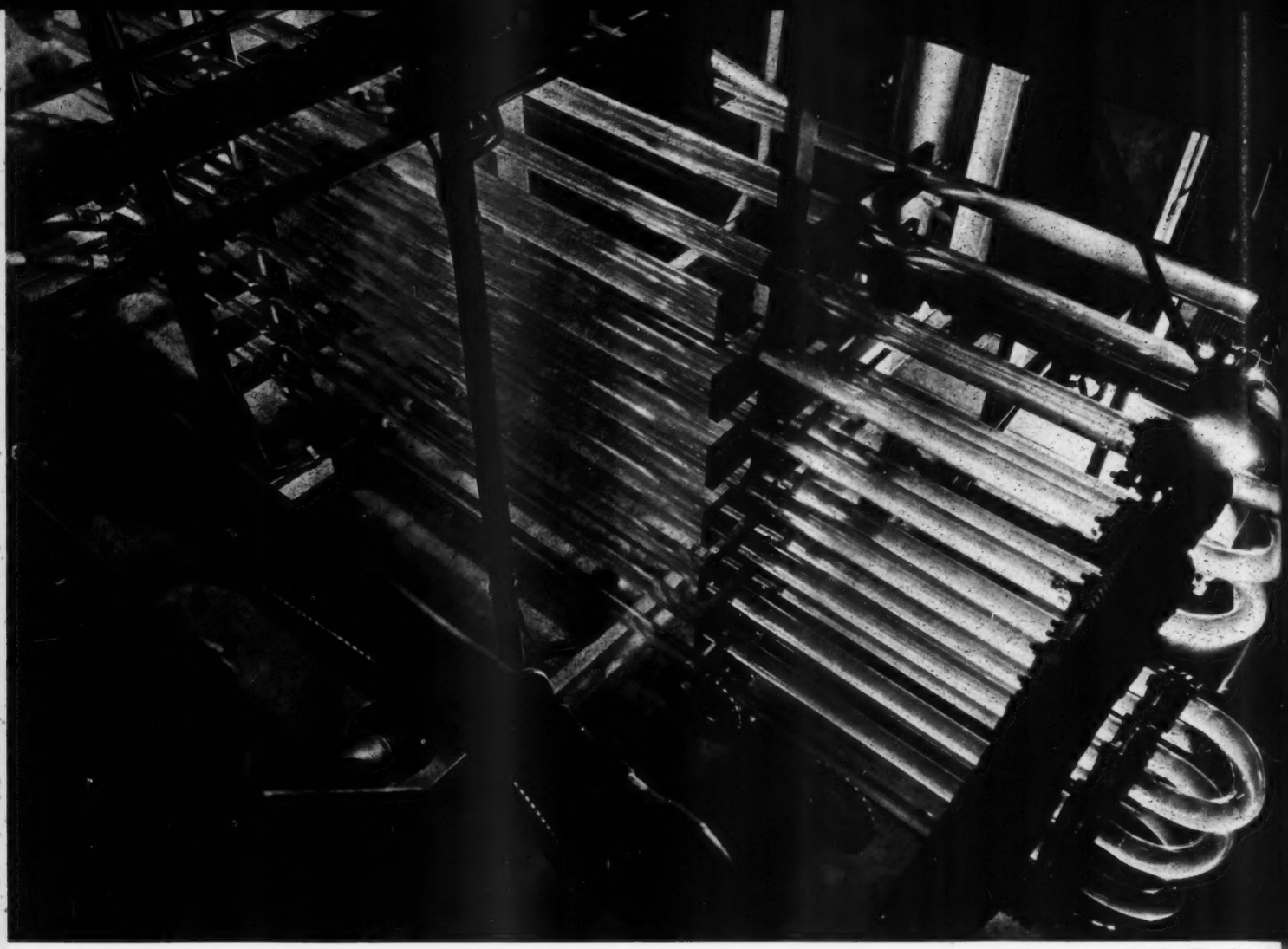


FIG. 13



Corning Glass Company

Radio station WLW, Cincinnati, uses Pyrex piping for cooling transmitting tubes and insulating a 12,000-volt amplifier

GLASS IN PARTS DESIGN

Its Properties and Applications

MANY of the physical properties of "Glass for Mechanical Parts" were presented in handbook style in November PRODUCT ENGINEERING, page 617. The following discussion covers some of the same ground with somewhat more detail presenting some of the pros and cons of glass applications. Glass is a complex chemical compound and there are as many different kinds of glass as there are different kinds of steel. Although brittle, glass has a high intermolecular strength in both tension and compression and is weak in practice only because of unavoidable surface flaws and internal strains and defects. Also, all glass is subject to gradual attack by all kinds of chemicals, organic and inorganic, and even to corrosion by ordinary moisture and humid air.

Nevertheless, glass is one of the strongest, hardest, most resistant substances known. Glass is also cheap, abundant and easy to fabricate. It merits, therefore, careful consideration of both machinery and product designers, especially now when most materials that are either hard or corrosion resistant are scarce.

FABRICATION OF GLASS. Glass can be cast solid, or blown into a "paste" mold, i.e. a carbon coated mold in which the ware is rotated, or blown into an "iron" (uncoated) mold without rotation of the ware.

Dimensional accuracy for molded glass is about the same as for iron castings in sand. For example, a cylindrical bottle shape designed to be 2 in. diameter, 4 in. long and with $\frac{1}{16}$-in. wall thickness, if blown in a paste mold to avoid ridges on the glass at the mold parting lines will vary as follows: Out of a lot of 100 bottles, a few will be plus or minus $\frac{1}{16}$ in. from the designed 4-in. length. A few others will be plus or minus $\frac{1}{16}$ in. from the designed 2-in. diameter. Another few will be plus or minus $\frac{1}{16}$ in. from the designed $\frac{1}{16}$-in. thickness. Most of the remainder will

be true to designed dimensions by half the above ranges. One-third of the lot can be selected closely true to any one designed dimension, such as diameter.

Glass blown in iron molds is much more accurate, but has a ridge at the parting line like an iron casting. When blown in an iron mold, the same bottle dimensions in a lot of 100 would vary only plus or minus $\frac{1}{32}$ in. on length, or plus or minus $\frac{1}{64}$ in. on diameter. The wall thickness, however, would still vary plus or minus $\frac{1}{16}$ in. as with paste molds. One-half of the lot can be selected closely true to any one designed dimension.

Certain glass shapes, such as small dishes, can be pressed between approaching dies, like a steel die forging. Dimensional accuracy is plus or minus $\frac{1}{64}$ in. in a dish 4 in. in diameter by $\frac{1}{4}$ in. wall thickness.

"Glass Welding." Glass can be and is joined together by "welding" or fusing during fabrication of certain glass products, glass building blocks for example. Glass parts to be joined together must be closely identical in chemical composition and thermal expansion coefficients. This contrasts with metals where solder, tin, copper, brass and steel can all be fused together in strong bonds, and is contrary to an existing impression that glasses are easily welded together. This is partly due to the fact that glass, being non-ductile, cannot stretch or cold-flow, even microscopically, to accommodate differences in the rate of contraction of the welded parts while cooling. Good manufacturing practice also demands a complete stress-relief anneal or "lehring" of all welded glassware. Within these requirements, glass is readily formed by bending, blowing and welding.

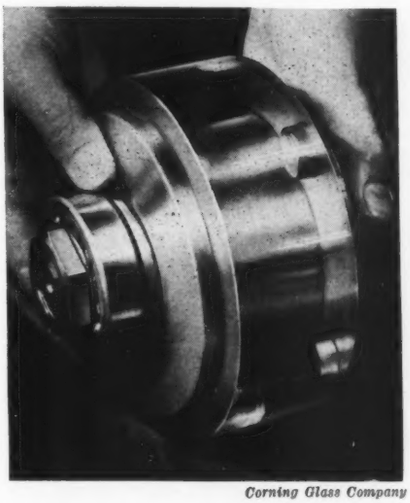
A new glass working tool which enables "welding" glass-to-glass faster, with closer control of temperature, greater concentration of the heating zone, and greater heat penetration, takes advantage of the electrical conductivity of glass at high temperature. With increased temperature glass changes from an insulator to an electrolytic conductor.

The welding process is accomplished by the passage of high frequency electric current through the glass by means of two or more electrodes in close proximity to the glass surface. One or all of these electrodes may be suitably conducting gas flames such as an oxy-hydrogen needle flame to form tiny conducting strips. While high frequency currents have been most successfully employed, it is also possible to use lower frequency at higher voltages and even direct current. The best operating frequency varies with the kind of glass, the type of ware and the exact nature of the operation.

Heating speeds may be 10 to 100 times that of the flame alone under ideal conditions. Production speeds have been doubled and even tripled on articles which come within the power range and control limits of present glass working machines. The principal difficulties encountered so far have been due, in general, to limitations in available equipment, rather than to limitations inherent in the process. As such they are rapidly being remedied by the development of better machines and power supply circuits.

Glass can be machined, but only with a diamond point, and with such difficulty as to be prohibitive from the cost standpoint. It can be drilled with less difficulty and is readily surface ground, edge ground, cylindrical and centerless ground, or lapped. The roughened surface from grinding operations, or from long exposure to atmospheric or chemical corrosion, can be "fire-polished" to produce a smooth glazed surface, with dimensional changes so small as to be in most cases negligible, except for pressure-tight lapped fits.

Corrosion Resistance. A glazed or fire-polished surface is more resistant to atmospheric or chemical attack than a mechanically polished surface, even though of optical smoothness. A mechanically polished surface is much more resistant than a ground surface. The glazed surface of a mechanical part made from a good grade of hard glass can be expected to withstand ordinary atmospheric attack for a year, and ordinary tap water for several months, usually much longer, without deteriorating enough to impair its surface gloss.



Corning Glass Company

Roller made of heat-resisting glass. Metal end plates secured to the glass by low melting alloy and axial screwed metal parts make a strong assembly

Corrosion resistance can be stated in terms of the National Formulary (pharmaceutical) Durability test. The glass sample is powdered and sieved to select a definite grain size, then 10 grams are heated with 50 cc. of water to 121 deg. C. in a steam autoclave. The corrodibility of the glass is then measured by the amount of alkali leached out of the glass by the water. The results vary from 0.12 for a non-corrosive chemical ware glass, to 6 to 7 for a good window glass, to as high as 15 for cheaper lime and window glass, and much higher for soft glasses.

More complete details on comparative chemical resistance of various glasses, as recently determined by the Bureau of Standards, were published in *Industrial and Engineering Chemistry, Analytical Edition*, June 15, 1941, p. 419-22, in tabular form.

Frictional Properties. Glass rubbing surfaces must be lubricated to prevent scratch and tear. Water may be used for light loads but oil, grease or graphite should be used for heavier loads. The dry coefficient of friction varies widely with the kind of glass but is a relatively unimportant characteristic of glass. Some grades of neoprene and cork compositions are available (on priorities) which have a coefficient of friction on a smooth dry glazed glass surface over 50 percent and far exceeding cork alone.

Thermal Shock Resistance. When using glass for machinery or product parts, the thermal shock factor should be the first to be considered. Ordinarily this property of a material needs little or no consideration and has been overcome to a large extent in glass by the development of such brands as "Pyrex," "Vycor" and others. However, since these glasses are relatively expensive the designer should first seek to reduce the thermal shock inherent in the operation of his design to the point where the cheaper and more easily fabricated glass can be employed. If considerable grinding or other finishing is required to attain the required shape or dimensional tolerances the cost of the glass blank is less important.

Coefficient of Thermal Expansion. This property largely determines the thermal shock resistance. For most glasses, it is approximately of the same order as for steel and cast iron, ranging from 3.3×10^{-6} per deg. F. for ordinary hard glass to 4.5×10^{-6} for thermometer glass and to over 5.5×10^{-6} for some plate and crown glasses. Values for leading makes of thermal shock-resistant glass are given in Table II of the above mentioned publication of the Bureau of Standards, averaging one-half

to one-fourth of the above values.

Softening point is defined by some glass manufacturers as the temperatures at which a glass rod first starts to stretch by its own weight, the unit stress being very low. Other manufacturers place the rod under a high transverse bending stress and give the softening point as the temperature of first perceptible quick yield, a more practical value from the mechanical design standpoint. This value ranges from 1,000 to 1,500 deg. F. for most glasses. Softening point of "Vycor" 96 percent silica glass is approximately 2,700 deg. F.

Glass is a true viscous material and flows at any temperature. But practically, the flow at room temperature is negligible, requiring years to become noticeable to the eye. However, when using glass under stress in a mechanical structure or product, under continuous loading or continuous high temperature, the desired dimensional stability and the degree of stress determine the permissible temperature, rather than the arbitrary softening point.

ELASTIC MODULUS. Data on this important property is scarce and vague. Tests by one manufacturer showed a range from 9.64 to 10.14×10^{-6} lb. per sq.in. for one particular hard glass composition. Lime glass rods in transverse bending averaged 13.4×10^{-6} when internally strained before loading, and 12.5×10^{-6} lb. per sq.in. when annealed before loading.

MECHANICAL STRENGTH. The intermolecular strength of glass is comparable with the strongest known materials, being somewhere between 500,000 and 1,000,000 lb. per sq.in. However, being completely non-ductile, hence unable to correct within itself the slightest surface or internal flaw, crack or defect, the safe practical working strength of a good grade of glass is only 1,000 lb. per sq.in. for tensile and bending loads.

The weakening effect of ever-present surface flaws such as microscopic scratches and bruises can be largely overcome by heat-processing or "tempering." This establishes a controlled, uniform, permanent, compressive stress in the surface layers of the glass and permits bending loads of 2,000 lb. per sq.in. or more, while at the same time increasing the range of permissible thermal shock.

Another expedient for partially nullifying the weakening effects of surface imperfections is "fortification" by hydrofluoric acid. This acid dissolves away a uniform layer from the surface of the glass and in so doing it rounds off the sharp corners and sharp leading edges of microscopic cracks or checks, thus preventing further migration of the tear or rupture under load.

A recent series of tests of lime glass and non-corrosive glass tubes and rods in transverse bending at continuous loading rates of 1,000 to 3,600 lb. per sq.in. per min., showed that the breaking load is insensitive to the loading rate, at least in this range. The breaking strength was also found to be roughly the same as for the particular lime glass and the particular non-corrosive glass of the test, and roughly the same over a range of beam lengths from one to five feet.

The maximum and minimum tensile strengths at break varied plus and minus 20 percent from the average values next tabulated (for annealed specimens):

	lb. per sq.in.
1 in. dia. tube 1½ mm. wall thickness	7,200
1 in. dia. tube 0.60 mm. wall thickness	6,000
½ in. dia. rod unscratched	6,700
½ in. dia. rod Scratched	3,800
¾ in. dia. rod Unscratched	6,800
¾ in. dia. rod Scratched	3,850
¾ in. dia tube, straight—fluted	6,500
¾ in. dia tube, helical—fluted	5,400

Note that the scratches reduced the ultimate strength 40 percent. Scratches were made as follows: A ¾-in. strip of No. 50 emery paper was twisted around the rod at the center until severe scratching was obtained which was readily visible to the naked eye as a band of several scratches running around the rod.

Strained (unannealed) specimens averaged 20 percent higher strength than tabulated above, but would be sensitive to thermal shock. Glass mechanical parts and products, unless made of pure quartz or Pyrex should always be annealed, or else strained under controlled conditions.

These and hundreds of other tests have shown that a safe working stress for glass rod and tubing is 1,000 lb. per sq.in. for quickly inspected members, and 2,000 lb. sq.in. for steady static loading through felt on rubber pads, or members which have no visible flaw in the stressed areas.

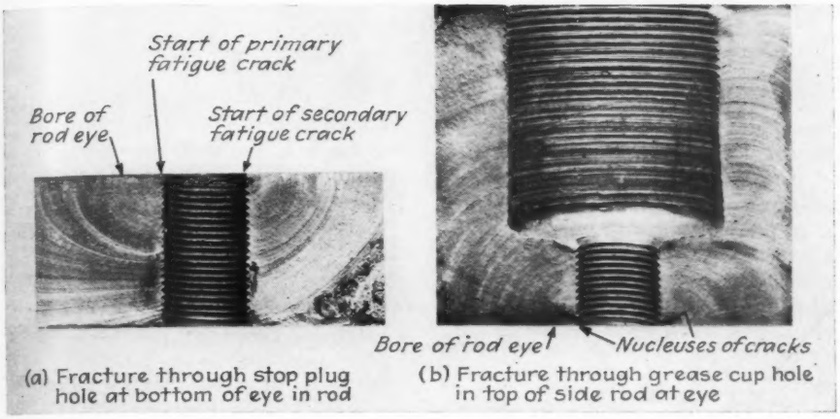
NOTCH RESISTANCE AND FATIGUE. Glass, being a non-ductile homogeneous substance, behaves in respect to fatigue strength and notch resistance, much like a highly tempered high alloy tool steel. Glass is more sensitive to sharp notches, sharp V-threads, grinding scratches, especially under repetition loadings. Glass is like a chilled white cast iron, extremely hard, but brittle and useless for shock and impact loads.

Glass parts, unlike metal parts, can be inspected for internal strains quickly and completely by means of a polariscope. Such polariscopes are in general use, not only in the laboratories, but through the manufacturing departments of glass manufacturers. If free from internal strains and free from any visible flaws such as seeds, bubbles or cords, and with a glazed surface free from microscopic cracks or checks, a glass part which has no sharp indents, V-threads, fillets, or drainage holes, can safely be used for long-life repetition loading not over 500 to 1,000 lb. per sq.in., depending on the cost of a failure.

DIMENSIONAL STABILITY. Unlike wood, fibre, and plastic parts, glass parts are not subject to dimensional changes due to moisture or exposure to humid air. Ordinary glass parts maintain a rigidity comparable with cast iron, up to temperatures over 800 deg. F., in contrast with many plastics, which soften at relatively low temperatures. At least one glass maintains rigidity at 1,700 deg. F. Parts made from one of the low-expansion glasses, which have a coefficient of thermal expansion only a fraction of steel, have a high degree of dimensional stability and freedom from warpage, over temperature changes of several hundred degrees. Such glass parts would be comparable with Invar in dimensional stability and in corrosion-resistance, and would be superior in hardness. Their thermal shock resistance would be ample for almost all applications unless exposed to continuous high stress at high temperature, when the glass would be subject to slow viscous flow, as noted above.

Because there are hundreds of different kinds of glass, sweeping generalities are likely to be fallacious. Although it is generally true, for example, that glass is sensitive to thermal shock, yet the low expansion glasses have a thermal shock resistance comparable to steels of similar hardness. Again the statement that "glass is subject to corrosive attack by ordinary moist air" is literally true, but the attack is slow, and parts made of a commercial grade of hard glass, fire-polished, can be expected to have better corrosion-resistance than any but the most expensive metals. In fact, where resistance to a sweeping wide variety of alkali and acid chemicals is concerned, (hydrofluoric acid alone excepted, glass is superior to all but the noble metals. Add to this extreme hardness, the ease of visual inspection for internal strains, extreme dimensional stability, easy production of lapped pressure-tight running fits, and easy fabrication of grinding, forming or welding—and glass becomes a material meriting a more widespread knowledge of its peculiarities and possibilities.

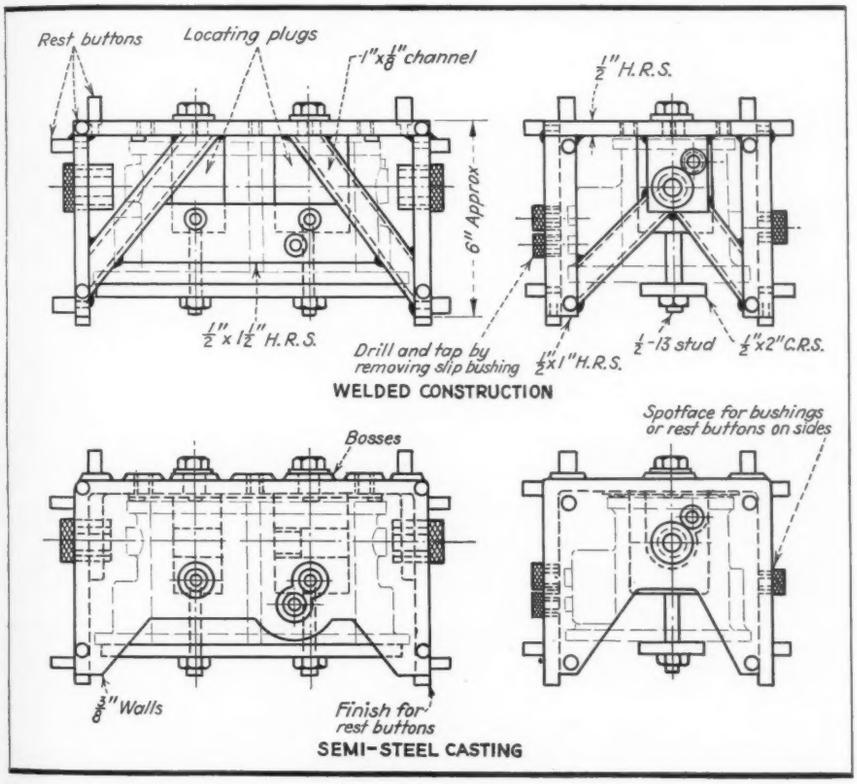
Causes and Cures


Start of primary fatigue crack
Bore of rod eye
Start of secondary fatigue crack
Bore of rod eye
Nucleuses of cracks
(a) Fracture through stop plug hole at bottom of eye in rod
(b) Fracture through grease cup hole in top of side rod at eye

Fatigue cracks starting at edges of tapped holes are clearly shown to be cause of these locomotive side rod failures. Fatigue cracks are results of stress reversals and defects; reduction of either of these factors will reduce number of failures.

In side rods, greatest stress is located at vertical axis through the eye; therefore, by moving these tapped holes back 45 deg. the stress is reduced. In failure shown at right, cracks started in thicker section where there is a boss. Thicker sections may be starting place for cracks more frequently than thin sections because thick section has less "give" and therefore creates greater stress concentrations. When boss is left off, failures are reduced. One authority even advocates a transverse undercut at hole, about ½-in. wide and 0.010 in. deep, milled or ground with grain of surface lengthwise of rod.

Defects need only be skin deep to cause failure and often are merely sharp burrs at edges, tool marks, minute cracks in work-hardened areas, or small inclusions. Edges of holes in side rods should have been rounded.



Aircraft carburetor body castings in production suddenly failed to pass inspection because various closely dimensioned hole centers were beyond drawing tolerances. The drilling jig was of welded hot-rolled steel, lightweight construction of the tumble type, rough-machined, normalized and finish-machined. After a thorough remachining and reboring job was done, the jig was put back in production, but within six months parts again were out of alignment. Apparently changes in temperature due to heavy drilling operations caused a "settling" or age readjustment of the welded structure. A new jig carefully designed with proper webs and lightening holes, made of semi-steel casting, rough-machined, normalized and finish-machined has been in use over two years with a perfect record of accepted parts.

TOTALLY-INCLOSED MOTORS are often installed in wet or cold places. In one instance two such motors were installed beside steam kettles. After only three months in service both broke down. When opened up 5 in. of water was found in each; the rotors were actually running in water. To cure this situation, which happens quite frequently, some manufacturers put small drain holes in the bottom of totally-inclosed motors.

LEATHER SEALS specified in direct acting shock absorbers for automobiles could not stand up under varied climatic conditions. The seal must withstand reciprocating motion and abrasive dust, and seals against a light oil which under severe operating conditions may attain a temperature in excess of 250 deg. F. After testing various materials, one manufacturer solved the problem with a special compound of neoprene and leather ground into a mass and then cured.

PRODUCT ENGINEERING will pay a minimum of $3 for each example published in Causes and Cures. Where illustrations are necessary, include drawings, rough sketches or photographs.

DYNAMIC BALANCING

Theory and Principles Governing Procedure

F. L. SCHWARTZ
University of Michigan

BALANCING rotating members is a problem in mechanics involving the equilibrium of forces and moments. All balancing machines operate by virtue of the same principles. The machines differ with each other only in the means used to determine certain positions and magnitudes of counterweights which bring an unbalanced rotor into balance.

Consider a rotor which is balanced to have attached to it a weight W, as shown in Fig. 1, thus causing the weighted rotor to be out of balance. If mounted in frictionless bearings and turned the weighted rotor will revolve, then oscillate and finally come to rest in a position such that the center of gravity of the unbalanced weight W is beneath the rotor in a vertical plane passing through the axis of the bearings.

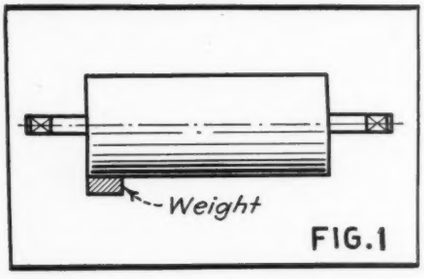


Fig. 1—Balanced rotor mounted in frictionless bearings with a weight attached which causes rotor to be out of balance

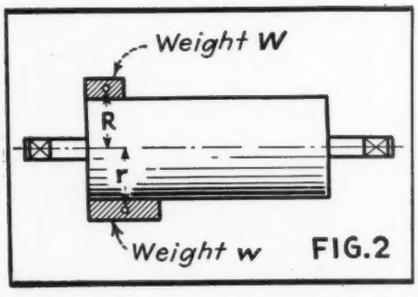


Fig. 2—Balanced rotor with two weights attached, one opposite the other in the same axial plane. If $WR=wr$, and the centers of gravity of the weights are diametrically opposite the system is in dynamic balance

The weighted rotor can be brought into static balance, that is, in a state so that it will remain at rest regardless of its initial position in the frictionless bearings, by attaching another weight w on the rotor opposite W, as shown in Fig. 2, so that WR equals wr. The centrifugal forces that act on the weights when the rotor revolves can be expressed in terms of

W or w = weight of unbalanced weight, lb.
R or r = distance from center of gravity of W or w to axis of rotation, ft.
ω = angular velocity, radians per sec.
g = acceleration of gravity, ft. per sec. per sec.
N = r.p.m. of rotor
K = constant which includes $1/g$ and conversion factor for ω
F' = centrifugal force on weight W

$$= \frac{WR\omega^2}{g} = KWRN^2$$

f' = centrifugal force on weight w
$= KwrN^2$

Forces F' and f', of course, act radially on the weights. If these forces are equal and opposite the rotor is said to be balanced dynamically and, of course, the rotor will also be balanced statically.

The rotor is balanced statically regardless of the position of W relative to w as long as the lines of action of F' and f' are parallel as illustrated in Fig. 3. If the lines of action coincide, the rotor is dynamically as well as statically balanced. If the line of action of f' is parallel but displaced sidewards to that of F' as shown in Fig. 3 the rotor is unbalanced dynamically because a couple acts on the rotor in the plane of the forces F' and f' which requires a counter couple produced by the bearings B and b, therefore, to balance this rotor the weights W and w must be removed or weights producing similar forces opposite F' and f' must be added. The centrifugal forces F' and f' are proportional to WR and wr respectively so that the constant of proportionality KN^2 may be dropped from further consideration. It should be remembered that WR or wr is proportional to a force even though it has the dimensions of a moment.

Considering a general case of balancing let a rotor be supported on bearings of a balancing machine at B and b, Fig. 4. Let C and c contain two arbitrary planes normal to the axis of rotation in which it is practicable to place or to remove metal to balance the rotor. Let P and p contain two arbitrary planes in which weights may be added temporarily while determining the weights and positions of the weights to be added in the C and c planes.

It is the purpose of the balancing machine to determine a weight W' at a radius R' in plane P and a weight w' at a radius r' in plane p which will balance the rotor. $W'R' = F_P$ and $w'r' = f_p$ may be replaced by electrical means but essentially the forces F_P and f_p or their equivalent must be measured. The forces F_P and f_p will not necessarily lie in the same radial plane.

Let the plane containing F_P and the axis of rotation be plane 1 and assume that it makes an angle θ with plane 2 which contains f_p and the axis of rotation. The usual way of determining F_P and f_p is to hold one support, say bearing b fixed and permit the other support B to vibrate in a given plane. Then determine W' and R' in plane P so that the support B does not vibrate. Then in a similar manner f_p may be determined by locking support B and permitting b to vibrate. An alternative is to keep one support fixed and the other one free and then invert the rotor in its bearings to determine the other force f_p after F_P has been determined. F_P and f_p are forces which when introduced one at a

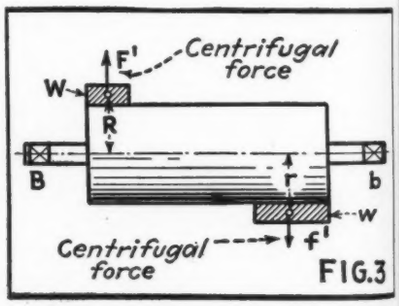


Fig. 3—Rotor with two weights attached opposite each other in the same axial plane. Rotor as shown is unbalanced dynamically because a couple acts on the rotor in the plane of forces F' and f' which require a counter couple to be produced at the bearings

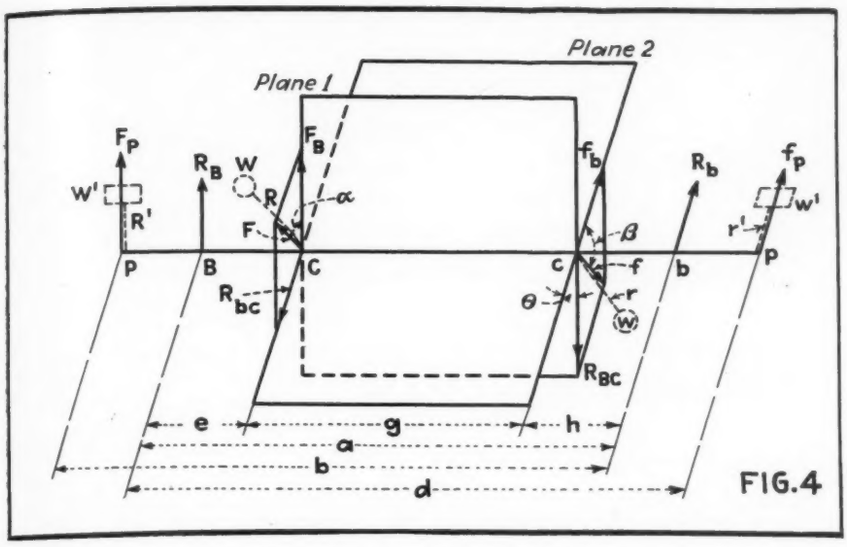


Fig. 4—Diagram showing magnitudes and directions of forces acting in an unbalanced system with forces that must be added to bring the system into dynamic balance

time produce balance of that end of the rotor about the fixed support at the far end of the rotor.

Taking moments M about b

$$\Sigma M = 0$$

$$(R_B \times a) - (F_p \times b) = 0$$

$$\text{or } R_B = \frac{b}{a} \times F_p$$

where R_B is an equivalent force at the bearing B.

Similarly, taking moments M about B

$$\Sigma M = 0$$

$$R_b = \frac{d}{a} \times f_p$$

The force R_B can be transferred through the distance e to C parallel to itself in the plane 1 by adding to the system the couple $R_{BC} \times g$ as shown in Fig. 5 such that

$$R_{BC} \times g = R_B \times e$$

Then by taking moments M about c in plane 1 and using R_B reversed since it is to be the equilibrant of the new set of forces, the conditions of equilibrium are

$$\Sigma M = -R_B \times (e+g) + R_B \times g + R_{BC} \times g = 0$$

$$R_B \times e + R_B \times g = R_B \times g + R_{BC} \times g$$

$$R_{BC} = \frac{e}{g} \times R_B$$

and the algebraic sum of the vertical forces V equal zero or

$$\Sigma V = -R_B - R_{BC} + R_{BC} + R_B = 0$$

The force F_B in Fig. 4 can then be expressed as

$$F_B = R_B + R_{BC}$$

Similarly, for plane 2 taking moments about C, as shown in Fig. 6

$$R_{bc} = \frac{h}{g} \times R_b$$

or in Fig. 4

$$f_b = R_b + R_{bc}$$

Now, as shown in Fig. 4, add F_B and R_{bc} vectorially to get their resultant F and the angle α. The counterweight W at radius R is the required balancing weight in the C plane. WR must equal F and W must be located at an angle α to the plane 1. In like manner f is the vector sum of f_b and R_{BC} and is inclined at an angle β to the plane 2 as shown in the illustration.

If the rotor is mounted in a cradle and the supports of the cradle are placed in the correction planes C and c, distances e and h become zero and a equals g. Then it becomes unnecessary to transfer the forces R_B and R_b to the planes C and c. This is the first simplification that has been introduced in the design of nearly all balancing machines. Some machines have one support fixed such as b placed in plane c and the other support free to move and then the force F_P is determined by trial and error on a compensating drum so that the free support does not move. Then the force f_p is found by inverting the rotor in its bearings and repeating the operation. Other machines have a drum which locates F_P automatically.

Another time-saving improvement is to be able to lock one support and permit the other one to be free and then by moving a lever unlock the locked support and fix the free support thus eliminating the necessity of reversing the rotor. Some machines measure a voltage which is proportional to the amplitude of vibration at the supports and thus obtain a reading proportional to F_P. By measuring the phase angle of the alternating voltage generated, the angle α is determined. A late type of balancing machine uses an electrical network to automatically locate the amount and position of the balancing weights. Electrical pickups measure the amplitudes at two supports and the electrical network performs the calculations thus giving direct and automatic readings for the position and amount of balancing weight to be added or removed.

Balancing machines which use compensating weights to locate the amount and position of balancing weights are

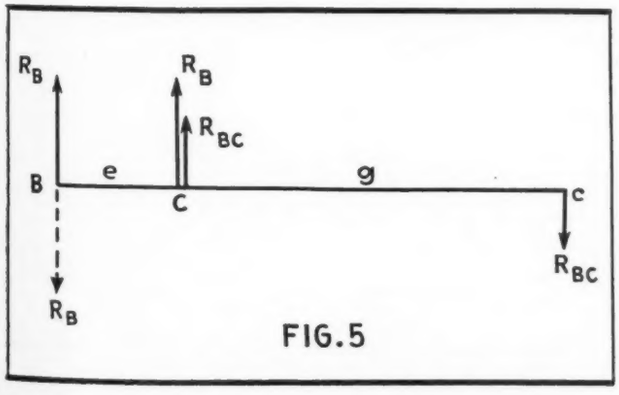


Fig. 5—Method of transferring parallel to itself the bearing reaction force acting in plane 1 by introducing a new force and a couple

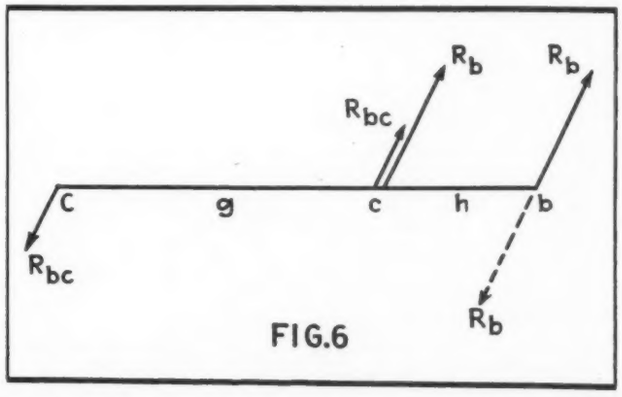


Fig. 6—Method of transferring parallel to itself the bearing reaction force acting in plane 2 by introducing a new force and a couple

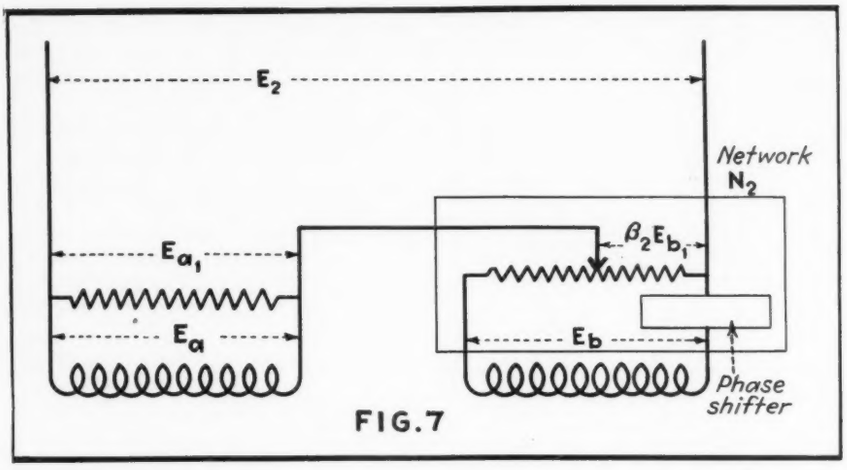


FIG.7

Fig. 7—Simplified diagram of an electrical system used on balancing machine for obtaining a resultant voltage which is proportional to the correction weight which must be added to dynamically balance a rotating system

usually made to hold the rotor in a cradle and use low balancing speeds. There is an advantage in using balancing speeds of the same order as the speed at which the part being balanced normally operates. In some rotors such as an armature of an electric motor there is a possibility of the parts (windings) shifting slightly when run at speeds higher than those used in the low speed balancing machines.

The latest type of balancing machine uses electric pickups which are inverted loud speakers at the bearings of the rotor being balanced. In this machine which is completely automatic the bearings are mounted on flexible supports. The voltage generated at each bearing is proportional to the amount of vibration at the bearing and by an ingenious electrical network a resultant voltage is obtained which is proportional to the correction weight to be added. A simplified diagram is shown in Fig. 7, of the electrical system. In this diagram, E_a is the voltage generated by the pickup at bearing A, and E_b is the voltage generated at bearing B. If the N_2 network is adjusted so that

$$E_{a1} = -\beta_2 E_{b1} \qquad (1)$$

when an unbalance is set up by an unbalancing weight w_1 only, then

$$E_a + \beta_2 E_b = E_2 \qquad (2)$$

Equation (1) is the defining equation for the network N_2 and is satisfied by adjusting the network N_2 during calibration of the balancing machine for a given setup. Equation (2) is the operating equation for the balancing machine and indicates that voltage E_2 which is proportional to and in fixed phase relation with w_2 equals E_a plus a proportion β_2 of E_b. These two voltages E_a and $\beta_2 E_b$ are placed in series. The network N_2 automatically performs the operation β_2 by shifting the phase and changing the amount of the voltage E_b to $\beta_2 E_b$. The voltage E_2 thus determines the correction weight w_2 to be added and furthermore E_2 has a fixed phase relation with the weight w_2 so that knowing this fixed phase relation, w_2 may be located. This is done by means of a stroboscope and suitable markings on the rotor.

By suitable switches a similar network N_1 for the other end of the rotor may be incorporated in the circuit and a voltage E_1 which determines correction weight w_1 may be determined. The rotor may be completely balanced with one run. It is not necessary to stop the rotor to reverse it or to reverse the fixity of one of the bearing supports. In this machine both flexible supports are free to vibrate at all times. Another advantage is that the rotor may be balanced in its own bearings, the bearings being supported on flexible supports. The necessary corrections for balancing may be obtained in twenty seconds.

Another type of balancing machine uses electric pickups at either end of a cradle holding the rotor, the cradle being pivoted at one of the correction planes. As the cradle vibrates horizontally about the pivot because of an unbalanced rotor, an alternating voltage is generated in the pickup at the opposite end of the cradle. The alternating current is rectified by a cam type commutator. The cam has two 180 deg. dwells and two sets of contacts 180 deg. apart are operated by the cam. The cam turns with the rotor being balanced. As the cam rotates it opens and closes the contacts each 180 deg. thus reversing the alternating current for 180 deg. of each cycle. If the cam is reversing the positions of the contacts at the instant the alternating current is zero two half positive sine waves result as in Fig. 8 (*A*) and a d.c. microammeter will read a maximum. If the cam is reversing the position of the contacts at the instant the alternating current wave is a maximum, that is, 90 deg. later, the resulting ammeter current will be zero, Fig. 8 (*B*). For any other position of the cam an intermediate value of current is read on the ammeter.

The location of the contacts relative to the cam may be shifted and as they are rotated a graduated scale of angles revolves with the contacts. Thus by moving the contacts until a zero reading is obtained the angle of unbalance can be read on the angle scale under a properly placed index. Then by moving the contacts 90 deg. a maximum reading is obtained and the magnitude of the ammeter current is a measure of the amount of unbalance in the unpivoted correction plane. By pivoting the other correction plane and allowing the first correction plane to be free and repeating the procedure the other correction weight may be determined. It should be recalled that in both types of balancing machines using electrical pickups two angles and two weights must be determined.

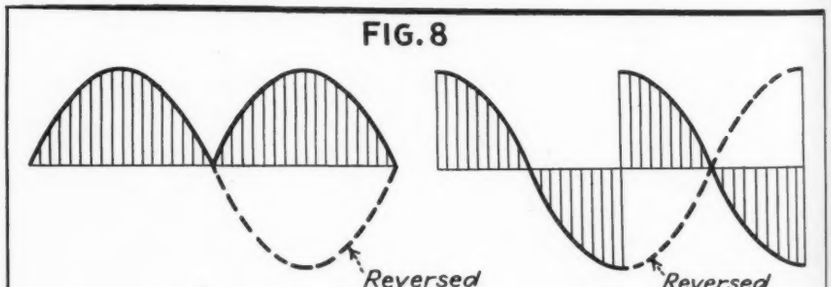


FIG. 8

Fig. 8—Graphical illustration of resulting ammeter current when alternating current is rectified by 180 deg. cam type commutator. (A) When cam reverses contacts at instant the alternating current is zero, two half positive sine waves result producing a maximum ammeter reading. (B) When cam reverses the positions of contacts at the instant the alternating current wave is a maximum the resulting ammeter reading is zero

Materials Section

STAINLESS CLAD STEEL

Stainless clad steel is a fabricating material available in plates, sheets, and strip coated on one or both sides. Numerous alloys are being combined successfully. Thickness of cladding is commercially practical, up to half the total thickness of sheet or plate.

ADVANTAGES

(1) Hard working surface and/or corrosion and oxidation-resisting surface backed by mild steel having good mechanical properties and workability.

(2) Lower cost than solid stainless steel when used clad on one side.

(3) Greater thickness than is practical by electroplating, metal spraying, or by impregnation by heat-treatment, and greater protection and resistance to penetration, particularly important where periodic cleaning is done by scraping or picking.

(4) Better heat transfer than through solid stainless. Bond zone between cladding and base metal is no obstruction to heat transfer.

(5) Conservation of chromium and nickel for defense.

Table I—Tensile Properties of Clad Metals

(RADEKER AND SCHONE)

Material	Thickness inches	Yield Strength lb. per sq. in.	Ultimate Strength lb. per sq. in.	Elongation percent
Base Metal				
Boiler plate.....	0.283	30,000	53,500	25.8
Coating material				
18-8 Cr–Ni steel....	0.031	40,000	88,000	47.5
Clad metal				
Experimental value..	0.315	31,300	57,100	27.2
Calculated value....	.....	31,000	56,600	27.3

Higher strength base metal is available in carbon steel having a physical value of 70,000 lb. minimum and 40,000 lb. minimum yield strength. If still higher tensile properties of base metal are desired, low alloy steels such as nickel steel, chrome steel, chromium-copper steel, or chrome molybdenum steel should be used.

CHOICE OF CLADDING

(1) Same as in selecting solid alloys. Commercial claddings vary from low straight chromium to complex nickel-chromium alloys with various other elements such as columbium, titanium, and molybdenum added for special properties.

(2) Choice between integrally and intermittently welded types is essentially a matter of cost comparison, according to T. S. Fitch, Jessop Steel Company. Intermittently welded type is generally more economical for plates over 1 in. thick. Integrally clad type is most economical for sheets and plates under a half inch thick. From ½ to 1 in. they are fairly even. Both types have amply proved themselves with respect to quality.

DISTORTION—WARPING—Stresses due to difference in coefficient of expansion of clad steel components produce no change in shape under 400 deg. F. Distortion tendencies during heating seem to be self-corrective both in flat plates and welded construction. In cooling there is no distortion above 600 deg. F. but from 600 to 400 deg. F. a change in shape occurs. In welded equipment this may be held within commercial limits by cooling through this range slowly.

In operating units which must pass through this range frequently, and often quickly, change does take place. However, design may be such that efficiency of operation is unaffected. There is no evidence that continued heating and cooling render a unit inoperative. Such heat changes have no effect on the union of components.

FABRICATING PERFORMANCE — Sheets and plates of stainless clad steel are generally easier to fabricate than solid stainless steel. Clad plates and sheets may be bent, spun into deep heads, and drawn without damage. They can be subjected to much more severe cold working without annealing than the same gage solid stainless. This is especially true of material clad on both sides. Fully annealed clad behaves more like ordinary boiler plate than like solid stainless.

COLD FABRICATING — Rolling, bending, braking, flanging, shearing, punching, and like operations may be done in the same manner as on ordinary steel or solid stainless. Best practice is to keep the clad side up to avoid gouges and scratches. This is especially advisable when punching and shearing.

Steel clad on both sides with 18-8 stainless has been deep drawn into a cup 6 in. in dia. and 7 in. deep with a uniformly thick coating, in three draws with no anneals between draws. The same cup made of solid stainless required four draws with an anneal between the second and third draw. In some instances the performance of armored steel in the draw press has enabled both a speeding

up of operations and larger draws without any increase in press power or size.

HOT FABRICATING—The same method of preliminary heating is used as with solid stainless. In hot braking, stainless clad steel plate should be held under the press until cold. If rolled hot, it should be rolled backward and forward until cold. Cold fabricating is generally preferable to hot fabricating.

MACHINING—A cobalt type high-speed tool gives most economical results in spite of higher original cost. Clad steels are easier to machine if they are fully annealed when supplied by the fabricator.

HEAT-TREATMENT—The value of proper heat-treatment is sometimes under-estimated, particularly on non-stabilized 18-8 stainless clad steel. After fabrication stabilized clad may be stress-relieved at the usual temperatures but non-stabilized clad steel must be stress-relieved below 1,250 deg. F. By increasing the time at the temperature, welding and machining stresses in the backing metal may be relieved as low as 1,100 deg. F.

If stabilized alloys are used as cladding, such as columbium or titanium bearing 18-8 grades, it is not necessary to anneal after fabrication to correct possible carbide precipitation which may have taken place during metallic arc welding. There is also considerable evidence that molybdenum bearing 18-8 grades, types 316 and 317, need not be annealed after fabrication so far as carbides are concerned.

To correct precipitated carbides in the unstabilized austenitic grades, they should be heated uniformly at approximately 1,925 deg. F., not under 1,850 deg. F., and then cooled quickly so that the stainless portion loses color within three minutes. The 12 and 17 percent chrome grades may be air-cooled from 1,450 deg. F. for softness, but should be furnace-cooled from a like temperature for optimum properties.

SURFACE CONDITION—Surface condition of cladding is comparable to that of equivalent solid stainless steel. Polishing is usually easier because the cladding is slightly softer and more speed is possible because the mild steel portion acts as a chill plate.

The surface of the backing steel is usually not as good as the finish of ordinary mild steel plate. However, the scale is usually fairly easy to remove and the surface takes paint well and gives a good appearance.

GRINDING AND POLISHING—Grinding and polishing by hand is practical on relatively small articles, such as lamp reflectors, on tanks or vessels where an optically uniform finish is not essential, and to finish welded or soldered joints. Hand grinding is not recommended where a comparatively large area has to be finished uniformly. Such surfaces should be polished prior to fabrication or special equipment may be required.

CLEANING—Special No. 1 finished cladding should be washed down with warm 5 percent nitric acid solution after fabrication to insure cleanliness and proper corrosion resistance. Excellent liquid and powder cleaners are also available. It is good practice to clean finished polished articles, even though they may appear clean to the eye. It is always possible that polished surfaces may have a little grease, oil dirt or other contamination on the surface which may later cause discoloration.

"RAW EDGE" TREATMENT

(1) Where stainless clad steel is used only for protection against hard usage, it is usually satisfactory to paint the edges.
(2) Up to and including 14-gage sheet, the edges may be crimped.
(3) Closed tanks require no special consideration since joints almost invariably are butt welded.
(4) The edges of heavier gages may be covered with stainless by any convenient welding method.
(5) Often a stainless clad flange may be incorporated into a design.

The problem of exposed edge of strip is being taken care of by beading the raw edge under the surface of the stainless.

GAS CUTTING—Gas cutting is practical only when the pattern is subsequently sheared or machined to remove the embrittled portion of the cladding. The embrittlement usually extends into the plate a distance equal to the thickness of the plate. Oxacetylene cutting has been used successfully for beveling the mild steel portion prior to arc welding.

WELDING—Welding technique for all types of clad steels has been highly developed. Detailed specifications for proved procedures have been accumulated and agreed upon by major producers of clad steels. The American Welding Society's new handbook, which will become available sometime after January 1, 1942, is expected to contain the most complete data yet published on welding clad metals.

Special precautions are generally recommended to prevent contaminating stainless with mild steel, thus producing brittle zones and causing carbide precipitation at the grain boundaries which reduces corrosion resistance. Continuity of the stainless must be maintained through the welds as well as through all joints.

A relatively simple lined vessel can usually be built more cheaply by resistance welding, whereas a complicated vessel can usually be made up cheaper with an integrally clad steel.

Welds made by the various proved methods surpass minimum requirements of A.S.M.E. and A.P.I. codes for unfired welded pressure vessels.

SOLDERING—The same precautions and procedure is specified for soldering stainless-clad sheet as for solid stainless. Generally speaking, good soldering requires special fixtures, and as it is difficult to effect a neat uniform joint, welding is preferred if practical.

In soldering a copper or bronze fitting to a stainless-clad sheet, silver soldering is the best method. Fluxes were made available recently which break down at a relatively low temperature, and which produce a fluxing action at the lowest melting point of any of the silver solders. At least one of these fluxes is miscible in water, making it advantageous in vertical or overhead soldering. Polished surfaces should be roughened slightly by etching with warm 10 percent nitric acid solution for about three minutes.

SIZES AVAILABLE

Stainless clad plates are available in practically all sizes in which solid stainless plates are available. Sheets are available as light as 21 gage, but 18 gage is normally the lightest gage made in commercial quantities. Sheet clad on both sides is available from at least one manufacturer in 22 gage. Requirements beyond this range are not impossible and should be referred to mills for consideration.

Sheets up to 70 in. max. width by 260 in. max. length are available although the lighter sheets may be somewhat smaller. Plate thickness is limited only by the maximum available in carbon steel plate. Plates over 5 in. thick are made almost entirely by the intermittent welding method. Widest clad plates are approximately 156 inches and the longest are about 400 inches.

MALLEABLE CAST IRON

Malleable iron is produced by subjecting white cast iron to a relatively long heat treatment to convert the combined carbon into free temper carbon, which is a form of graphite. Outstanding characteristics of malleable iron are its ductility, shock resistance and strength, ease of machining, and corrosion resistance. Pearlitic malleable iron, which contains some combined carbon, is also used where higher resistance to abrasive wear is required. It shows higher strength, yield point, and fatigue resistance, but lower ductility or ease of cutting. Its rigidity is considered in many applications.

A LARGE PERCENTAGE of malleable iron production is used for automotive parts such as steering gear housings, differential cases and carriers, rear axle housings, spring hangers, and other parts. Defense equipment is now taking large quantities.

MOST MALLEABLE IRON is bought on specifications based on tensile strength, yield point and elongation. These properties can be varied, though not independently, by changes in carbon content. If pearlitic malleable is to be used, then further changes can be made by appropriate selection of heat-treatments. Considerable ingenuity has been exercised independently in developing heat-treatments and compositions in the pearlitic malleable irons to retain ductility with desired higher tensile strength.

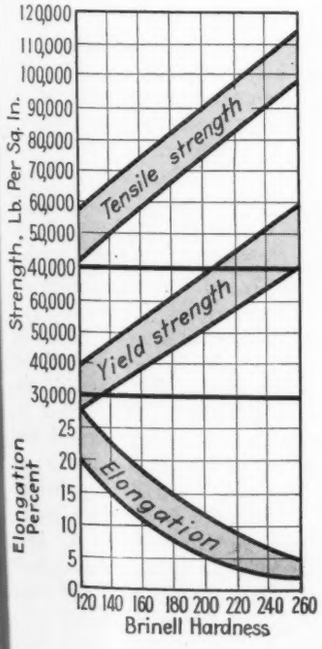
Table I—Physical Properties of Malleable Iron

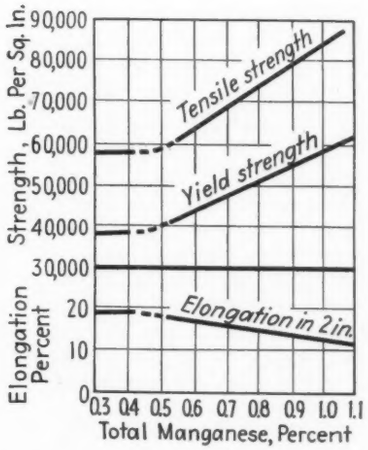
A.S.T.M. Specification	A47–33 Grade 35018	A47–33 Grade 32510	A197–39* Cupola Iron
	Probable Values		
Tensile strength, psi	57,000	50,000	45,000
Yield point in tension, psi	37,500	32,500	35,000
Elongation in 2 in., percent	22	14	8
Modulus of elasticity, psi.:			
In tension	25,000,000	25,000,000	27,800,000
In shear	12,500,000	12,500,000	.....
Ultimate shearing strength, psi	48,000	48,000	.....
Poissons ratio	0.17	0.17	.....
Yield point in shear, psi	23,000	23,000	.....
Modulus of rupture in torsion, psi	58,000	58,000	.....
Brinell hardness number	110–145	.....	110
Charpy impact value, ft.-lb	16	12	5
Izod impact value, ft.-lb	16	12	8
Fatigue endurance limit, psi	25,000–26500	.....	.....
Shrinkage allowance, in. per ft	1/8	1/8	.....

* See also ASTM Tentative Specification A220—39T.

Tensile properties in the first three lines refer only to standard test specimens and not to specimens machined at random from any part of a casting. Other data in the table are not included in the ASTM specification.

Grade 32510 is not as strong as 35018 but is more easily cast in light sections and does not require as large feeding heads because its higher carbon content increases fluidity and lowers internal shrinkage, one authority has stated. It has adequate strength for nearly all general use and has been found to machine more satisfactorily than the stronger grade.





STRENGTH

Malleable iron castings seldom fail under compression or transverse loading because the material flows indefinitely, being made useless by deformation before fracturing. Malleable iron takes a permanent set of 1 percent at about 28,000 lb. per sq. in. in compression.

Tensile strength decreases as the carbon content increases, in general. Increase in temperature has no effect up to 800 deg. F. but strength drops rapidly above this temperature. At 1,200 deg. F. it is only 20 to 25 percent of normal temperature strength. Elongation also rises rapidly.

Decreases in unit tensile strength with increasing diameter of section are approximately proportional to the cube of the diameter and decreases in elongation are proportional to the 5/2 power of the diameter.

(*Continued on next page*)

SAFETY FACTOR—Little extra for safety to offset the "factor of ignorance" need be introduced into engineering calculations because of uniformity in structural composition. Blow holes or non-metallic impurities rarely occur.

MACHINABILITY — No ferrous material of equal tensile properties can be machined with equal speed and tool life. Threading and other machining operations on pipe fittings are performed at high speed. To obtain desired machining speeds, as well as smooth, accurate threads and surfaces, a higher carbon malleable iron produced with some sacrifice in ductility and strength is much used for pipe fittings, according to one authority. Another reports that the anneal, rather than the original carbon content, is the factor having the greatest effect on machinability.

PUNCHING — Punching is a simple operation because of extreme ductility. A ¾ in. hole in a ⅝ in. plate can be enlarged by drifting to 1½ in. without developing incipient cracks.

CORROSION—The excellent rust-resistant properties of malleable iron as compared with other ferrous products are well known from observations of castings which have seen service many years, such as fittings on iron fences and tie plates in railroad track service.

WELDING—Malleable iron cannot be successfully welded because the temper carbon reverts to the combined form. For the same reason it should not be used at temperatures above 1,200 to 1,300 deg. F.

BRAZING — Malleable iron can be brazed with Tobin or manganese bronze rod. Surfaces to be brazed should be cleaned thoroughly and tightly fitted together before brazing.

FLAME HARDENING—Surface hardening can be done successfully with the oxyacetylene flame, Stephen Smith, Air Reduction Sales Company told the American Foundrymen's Association last May.

Rockwell hardness of C42 to C58 has been produced on various malleable types. File hardness can be obtained at Rockwell C55 as compared with C60 required for steel. Maximum hardness is obtained by heating about one minute and quenching. Too long or too rapid heating are detrimental.

Parts should be designed with flame hardening in mind for best results. Flame hardened sections should be uniform in thickness and simple in shape. Large surfaces with projections over 1/16 in. high should be avoided when progressive hardening is required. Where hardness in corners or grooves is desired generous fillets should be introduced. Unequal heating and cooling causes warping.

CASTING DESIGN—The same principles apply as for good steel castings. The average section used is about ⅝ in. Malleable iron can be cast in practically any required section, however, and patterns may be designed to minimize machining. Most satisfactory castings from the standpoint of quality, service, and economy will result from heeding the following design hints whenever practicable, although they are not prerequisites.

Sections—Make as uniform in thickness as possible, avoiding abrupt changes in section by using a gradual taper or ribs so as to reduce heat and stress concentration.
Ribs—Locate ribs where they can be fed and, when they connect light and heavy sections, make them thick enough to feed metal through to heavy parts.
Fillets—Make as large as possible.
Re-entrant Angles—Should be avoided.
Deep Pockets and Small Recesses—Should be avoided.
Locating Points—Should be held to one side of parting to eliminate trouble in machining. Drawings should show machine shop locating points.
Tooling Fixtures—Dimensions which have no finish allowance and are held to close limits should be considered as proper places from which to start development of tooling fixtures.
Dimensions—Should not be held to closer tolerance limits than necessary on account of warpage.

Choice of Design—If there is an opportunity to choose between a single large, light-weight cored or intricate casting and an assembly of two or more smaller ones, the latter is preferred. If quantity justifies, strengthening dies may be employed to correct warping. Other factors in design are the possible use of a coining press, which eliminates many finish allowances, or the use of disk grinding operations with reduced finish allowances.

ALLOYS—Few alloying elements have proved practical. Only copper and perhaps molybdenum have so far been of any importance. Copper somewhat facilitates annealing, improves strength, and to some extent, ductility when present in an optimum amount of about one percent. A 2.3 percent carbon iron containing 0.20 percent molybdenum and 0.5 percent copper has a yield point of 40,000 lb. per sq. in. or more, and an equivalent increase in tensile strength. Elongation is not affected. These alloys can be hardened with considerable increase in strength and indentation hardness, and little effect on ductility.

If melting and casting practice allows as much as 1.5 percent silicon in the white iron, physical properties similar to those produced by alloys of copper molybdenum can be had in fully annealed iron, it is reported. The use of an increased silicon content in the presence of molybdenum also seems to have some merit. A strengthening effect resulting from small additions of aluminum has been reported in one application. It is also possible to alloy malleable iron with enough chromium and aluminum to permit of nitriding.

One investigator found optimum strength in an alloy containing 0.84 percent chromium and 1.57 percent silicon but reported no way to prevent a drop in ductility. The additions were made for wear resistance. Elastic limit increased to 62,500 lb. per sq. in. and hardness increased but elongations decreased with increases of chromium.

Specifications for alloyed malleable iron should not be written by the consumer without consultation with the prospective producer. The effect of alloying is somewhat complicated and the practicality of adding particular alloys depends upon production methods, especially when the alloying would have an effect upon the heat treatment. Alloy additions not consistent with a producer's experience and practice may thus prove unobtainable.

LAMINATED PLASTICS

Produced through the reaction of pressure and heat upon plies or layers of paper sheets or fabric that have been impregnated with heat-hardening varnish, laminated phenolic materials because of their hardness, water and heat resistance, mechanical and dielectric strength, and chemical inertness are being used for many parts which were formerly made of steel, iron, aluminum, brass, bronze, lead, wood, rubber, glass, asbestos, porcelain, leather or paper.

KINDS OF SHEET MATERIAL USED FOR LAMINATED STRUCTURE

Paper, linen, cotton fabric, canvas, asbestos paper and cloth, glass cloth, paper plus cloth and mica plus paper are all used as filler materials. Each base material, of course, has properties peculiar to itself which when combined with various kinds and varying percentages of resinoid binders make the finished laminated material suitable for specific fields of application.

PAPER BASE GRADES, because of their electrical properties, find wide application for electrical equipment and radio parts in the design of which insulation value and resistance to moisture are important, and at the same time mechanical strength and impact resistance properties are secondary. The presence of the paper layers increases the tensile and compressive strengths considerably above those obtained with the resinoid alone.

FABRIC BASE GRADES have higher physical strength properties than the paper base grades and consequently are used for parts in which strength is the determining factor as in gears, cams, bearings and levers.

CANVAS BASE LAMINATED has high compressive and tensile strength and shock resistance. This material is often used for gears on motors driving heavy machinery because it can absorb the stresses set up during starting, stopping and reversing operations. Gears made of laminated phenolic materials are light in weight as compared to gears made of metal. Therefore, the inertia forces inherent in starting and stopping high-speed machines can be reduced through the use of gears made of laminated plastic materials. These materials are also not affected by temperature changes, exposure to oil, water, or to many corrosive chemical atmospheres or solutions.

Gears made of laminated material should always mesh with cut metal gears. The width of the face of the metal gear should never be less than that of the laminated gear. Allowance for backlash must be made when cutting the teeth and during assembly, otherwise, the teeth may wedge because of thermal expansion and thus break down the tooth structure, spread the laminae or change the tooth profile.

APPLICATIONS

Grooved pulleys	Drop hammer boards
Breaker strips	Rotary pump vanes
Fan blades	Bearings—Gears
Tank linings	Electrical parts
Washers	Suction box covers
Shaker springs	Instrument panels

Heads and frames of plating barrels
Covering for paper machinery rolls
Decorative purposes and furniture
Pipes for the chemical industry
Pump valves and piston rings
Blocks for mounting engines
Spinning buckets for rayon
Sheathing for metal bars
Rail joint insulators

LINEN FABRIC makes an impact resistant product that has a close structure so that when machined it has a fine grained appearance. Linen base materials are particularly suitable for cut gears of small face dimension and also for punched parts because the close texture can be cut with clean smooth edges.

ASBESTOS BASE MATERIALS because of their high inorganic content are more resistant to flame and slightly more resistant to heat than the other laminated grades. These materials are characterized by low water absorption and high dimensional stability.

RUBBER LAMINATED is a special material consisting of layers of soft rubber "sandwiched" between sheets of phenolic laminated. Many combinations are possible. The thicknesses of the layers may be varied as well as the number of alternating layers of rubber and laminated material. Rubber laminated is sometimes used for vibration absorption mountings where resiliency and sound-deadening qualities are desirable.

GLASS FABRIC BASE MATERIAL is a recent development, it is suitable for mechanical and chemical applications. Glass fabric base material has high impact strength and resistance to cold flow. Since glass is attacked by most alkalies, glass base laminated is not desirable for applications where alkali-base materials are present, however, its acid resisting properties are excellent.

MICA PLUS PAPER LAMINATED MATERIALS are used for many parts where heat-resisting and electrical insulating properties are required. These properties increase in value as the proportion of paper in the combination decreases, however, mechanical strength and machining properties improve as the paper content increases.

STANDARD FORMS AND SHAPES—Sheets and plates are made in sizes up to 50x110 in. Thicknesses range from $\frac{1}{64}$ up to 2 inches.

Tubes are either rolled or molded. Rolled tubes are made by winding the material on a mandrel under heat and pressure, and are usually baked while thus mounted. Molded tubes are also wound on a mandrel but the heat-treatment is applied in steel molds which size the outside diameter of the tube. Tubes are made in lengths up to 120 in., inside diameters range from $\frac{3}{16}$

up to 72 in., with $\frac{3}{32}$ to $1\frac{1}{2}$ in. wall thickness.

Paper base rolled tubes generally have better dielectric strength, power factor and dielectric constant than molded tubes, however, moisture absorption is usually higher. Where concentricity of outside and inside diameters is important rolled tubes are generally recommended.

Rods of circular section are made by winding the impregnated fabric on a wire and then molding after the wire is withdrawn. Rods can also be machined from cut sheet or plate stock.

Special shapes include rods and tubes of non-circular section, also angle and channel sections.

GENERAL PROPERTIES OF LAMINATED PLASTICS

PHYSICAL. Dense solids of uniform structure free from variations. Surface is generally smooth, can be produced with a high lustre. When cut at right angle to filler material the laminations are visible.

Colors are usually black or natural brown. With color printing process it is possible to produce pictorial and design effects on the surface at time of fabrication. The translucent and graphic laminated materials can be produced in any of several colors.

Need no surface finish such as paint or varnish, plating or polishing.

Table I—Properties of Laminated Plastics

(Data furnished by the Bakelite Corporation)

Properties	All types		Typical Averages	
	Minimum	Maximum	Paper Base	Fabric Base
Specific gravity	1.32	1.41	1.36	1.38
Oil absorption	Nil	Nil	Nil	Nil
Water absorption, 24 hr. Sample 1X3X1/8 in., percent	0.2	3.0	0.5	0.9
Resistance to heat, safe limit for constant temp. Deg. C	90	150	125	110
Deg. F	194	300	257	230
Hardness, sample flatwise Brinell	30	40	40	38
Scleroscope	70	94	80	72
Coefficient of expansion, sample lengthwise, per deg. C	0.00002	0.00003	0.00002	0.00002
Tensile strength, ultimate, lb. per sq. in	8,500	24,000	12,000	10,000
Modulus of elasticity from flexure test, lb. per sq. in	700,000	2,500,000	1,500,000	1,000,000
Flexural test, ultimate strength, lb. per sq. in. Sample flatwise	13,000	30,000	21,000	20,000
Sample edgewise	12,000	24,000	20,000	20,000
Compression test, ultimate strength, lb. per sq. in. Sample flatwise	30,000	40,000	30,000	40,000
Sample edgewise	18,000	35,000	18,000	22,000
Shearing test, ultimate strength, lb. per sq. in. Sample flatwise	7,000	11,500	10,000	9,000
Sample edgewise	8,000	10,000	10,000	9,000
Dielectric strength, short time test, volts per mil thickness 1/8 in. sample	400	900	700	450
1/32 in. sample	400	1,400	900	550
Dielectric constant, 10^6 cycles per sec	4.5	6	4.5	5.5
Power factor, 10^6 cycles per sec	0.020	0.10	0.035	0.08
Volume resistivity, ohm per cm	10^{10}	10^{13}	10^{12}	10^{10}

Values given in this table under the heading " All Types " are shown for the purpose of indicating extreme results of tests from samples made with paper, linen, canvas and asbestos bases, and with various degrees of resinoid impregnation. The values given for paper base and fabric base materials are typical for two specific grades. Space does permit listing here the properties of all the grades available. See *P.E.* August, 1940, p. 363 for table of Average Standard Properties of Laminated Phenolic Plate, based on Standard A.S.T.M. Tests.

MECHANICAL

Light weight
High tensile, compressive and flexural strength. In general within limits the strength increases as the resin content decreases.
Impact resistant and shock absorbing, do not readily split or break.
Hard, do not soften under heat, unharmed by temperatures up to 230 deg. F.
Low cold flow.
Low thermal conductivity, low coefficient of expansion.
Resilient.
Sound and vibration absorbing.
Wear evenly under sliding contact.

ELECTRICAL

High dielectric strength derived from resinoid binder. In general the dielectric strength improves as the proportion of resinoid increases.
Low power factor.
Low moisture absorption.
Low dielectric constant.

CHEMICAL

Completely polymerized and hardened resinoid binders are not attacked by most reagents, solvents and oils, also by most organic acids and dilute mineral acids. However, the resinoids are attacked by hot alkaline solutions.

In the selection of a laminated plastic material to resist chemical action, the choice of the base or filler is important. Cellulose cloth and paper, asbestos and glass each have their field for chemical resistance.

Cellulose paper is difficult to impregnate thoroughly. Water absorption is comparatively high and chemical resistance decreases with capacity to absorb moisture, therefore material with this base should be avoided where resistance to chemical action is desired.

Cellulose cloth base materials are suitable for applications where weak acids, weak bases and low concentration of salts or neutral salts in any concentration are encountered.

Asbestos base materials should be used only when strong alkaline conditions are encountered or when the part is exposed to salts in high concentration which tend to hydrolyze or split to alkaline radicals. Asbestos, being alkaline, is easily attacked by acids and acid salts, even in low concentration.

Glass-base is easily attacked by alkalies in all concentrations, but is the most acid-resistant material available.

LEAD COATINGS

High-lead low-tin alloys for hot-dip coatings are becoming important in many applications as an alternate for tin plating, for high tin-lead coatings such as terne plate, for zinc galvanizing, and for tin-lead solder. Although ordinary hot-dip lead coatings do not adhere to sheet metal unless an undercoat of terne plate (80 percent lead, 20 percent tin) is first put on, a series of lead-tin alloys tradenamed "Amaloy" contain only ½ to 10 percent tin. Good wetting power and adhesion are obtained in these alloys by adding constituents amounting to a few hundredths of one percent. Process is similar to galvanizing.

HOT-DIPPING PROCESS

DEGREASING—Oil and dirt on the part to be coated should be removed in hot caustic or electrolytic caustic cleaning baths. Temperature of these baths is between 200 and 210 deg. F. Soap should be rinsed off with hot water. Vapor degreasing is equally effective for removing oil films.

PICKLING—Steel should be pickled in a warm hydrochloric acid pickling bath to remove oxides. Bright copper and other clean finishes need not be pickled.

FLUXING — Zinc chloride-ammonium chloride flux is applied before dipping, the same as for galvanizing.

DIPPING—The part is dipped into the Amaloy bath immediately after fluxing. Bath temperature is maintained between 675 and 750 deg. F. Alloys with higher tin content have bath temperatures in the lower end of this range. The part must be immersed long enough to reach bath temperature. Since iron floats on lead, parts must be forcibly immersed.

THICKNESS OF COAT — Approximately ⅔-oz. of lead alloy per sq. ft. is deposited. Resultant coating is 0.0006 to 0.0007 in. thick. Slightly heavier coatings result from baths with lower temperatures.

COOLING—Low-tin high-lead coatings can either be air cooled or quenched. Air-cooled coatings are bright and shiny, quenched are dull. Quenching is by dipping in water or spraying. Water should be softened with soap.

PROPERTIES OF LEAD COATINGS

CORROSION RESISTANCE—If a lead coating over iron is scratched, corrosion will attack the base iron; but if a lead coating over copper is scratched, the lead will be attacked. Compared with zinc, lead coatings are superior where common acids are present. In other applications over iron or steel, lead is slightly inferior in corrosion resistance. Lead is better than zinc on copper or brass because lead is electrolytically closer to copper, hence electrolytic action is less.

DENSITY AND ADHERENCE — Low-tin high-lead hot-dip coatings of ordinary thickness have slight pin holes. Amount of pin holing is found to be less than with ordinary lead-tin alloys, and is more pronounced in air-cooled coatings than in quenched coatings.

CHEMICAL PROPERTIES—Alloys for low-tin high-lead coatings do not attack steel melting pots as does zinc. There is no bath contamination when coating over copper or brass because the lead dipping bath does not absorb copper as do zinc or high tin alloys.

FORMING—Amaloy coated steel can be formed and bent without the coating flaking off. Its ductility in this respect is superior to that of zinc coatings.

TEMPERATURE LIMITATIONS — Amaloy coatings are applicable for temperatures up to 500 deg. F., and are good down to low temperatures. Low tin content eliminates brittleness and flakiness at low temperatures.

ABRASION RESISTANCE—Soft lead alloys are not recommended for applications where the coating is subject to abrasion. Amaloy is harder than pure lead.

PAINT FINISH—Practically any kind of paint can be applied directly over lead coatings. The bond is better than that of galvanized coating.

WEIGHT OF ALLOYS—Weight of Amaloy alloys vary, depending upon tin content. Weight of 2½ percent tin alloy is 703 lb. per cu. ft.; 10 percent tin alloy weighs 684 lb. per cu.ft.

TYPICAL APPLICATIONS

Low-tin high-lead alloy coatings, as developed thus far, can be applied to almost any base metal, including steel, copper, malleable iron, brass. Cast iron can be coated only with difficulty; sand burned into skin causes poor adhesion and coverage. Principal application is as an alternate for zinc galvanizing and tin plating. Other applications are:

AIR-CONDITIONING—Lead coatings are replacing high tin solders in dip soldering and coating of copper air-conditioning coils and refrigeration condensers. Principal requirements are good thermal bond and corrosion resistance. Low temperature of lead bath does not take the temper out of fins, as zinc baths sometimes do.

COPPER WIRE—Sulphur in rubber covering necessitates a thin corrosion-resistant metallic coating over copper electrical wire. Amaloy coatings now being substituted for tin are found to stand up better than tin and have been approved by the U. S. Army Signal Corps and the Underwriters' Laboratory. Coating is wiped with an asbestos wiper after dipping to a thickness of 0.0003 in. Copper wire screen is also a new application where tin was formerly used. In this case the coating is slightly heavier than the previous tin coating, and is not wiped off.

BATTERY HARDWARE—Lead coatings, resistant to common acids, give good corrosion protection to storage battery clips, bolts, cables, and handles. For similar reasons, the coatings are applied to flue-gas heat exchangers.

CARTRIDGE BRASS

R. A. WILKINS and E. S. BUNN
Revere Copper and Brass Incorporated

CARTRIDGE OR 70-30 BRASS is an alloy of copper and zinc containing 70 percent copper. Due to the extensive use of this alloy in the manufacture of cartridge cases and other ammunition component parts more cartridge brass is being manufactured than all other types of copper-zinc alloys.

This alloy possesses the best combination of ductility and strength of all the brasses. Cartridge brass has excellent cold working properties and can be readily spun, drawn, forged and upset. Its hot working properties are not as good as the higher zinc alloys but if in its manufacture care is taken to keep lead, a common impurity, to 0.05 percent or less, no difficulty will be encountered.

Cartridge brass conforms to the following specifications: Sheet and Strip—U. S. Army 50-46-1B, 57-172-1B, 57-172-2A, 57-173-1B; A.S.T.M.—B19, B129, B36; Federal QQ-B-611a and SAE No. 70; Rod and Bar A.S.T.M. B134; Federal QQ-B-611a, QQ-W-321; Pipe and Tubing—A.S.T.M. B14, B135.

Complete mechanical properties of cold worked and annealed strip and rod are given in the accompanying charts. In Product Engineering, Aug. 1941, page 436, is given a table of the general properties of cartridge brass.

In the cold working as well as in the annealing series for strip, properties are given for two different ready-to-finish grain sizes, 0.015 and 0.070 mm., which represent limits commonly encountered in commercial annealing. Cartridge brass rod is commonly rendered sufficiently malleable for cold drawing by annealing prior to cold working so as to produce a grain size of 0.045 mm. to 0.050 mm.

In brass mill terminology the anneal before the final cold working is called the "ready-to-finish" anneal and the grain or crystal size obtained is called the "ready-to-finish" grain. Commercial practice was followed in establishing mechanical properties given in all of the following charts. These charts, especially the cold worked strip series in Figs. 1 to 4, show that the mechanical properties are markedly influenced by the ready-to-finish grain size.

In the fabrication of brass strip the amount of cold work performed is referred to as the B. & S. numbers hard, e.g. all brass sheet and strip thicknesses are based on Brown & Sharpe gage units. See Product Engineering, Oct. 1941, p. 552, for the relation between numbers hard, percentage reduction of area by cold working and commercial temper designations.

A different range of properties is of course established for each number of hardness as shown in Figs. 1 to 4. This range is typical of commercial production and as such is recognized in commercial specifications. Control of the ready-to-finish grain size from one lot to another for a given amount of cold work is essential in securing identical properties in strip brass or cartridge brass. Fig. 2 shows that material having a ready-to-finish grain size of 0.015 mm. and cold worked 3 numbers has the same tensile strength as material with a ready-to-finish grain size of 0.070 mm. cold worked 5 numbers hard.

The influence of the ready-to-finish grain size on material which has been cold worked 6 numbers (50 percent reduction) and then annealed (Figs. 5, 6, 9 and 10) is less marked but nevertheless as important. Material having a ready-to-finish grain size of 0.070 mm. has consistently lower mechanical properties at the given annealing temperatures than material having a ready-to-finish grain size of 0.015 mm. Grain growth has taken place more rapidly in the material having the larger "ready-to-finish" grain size.

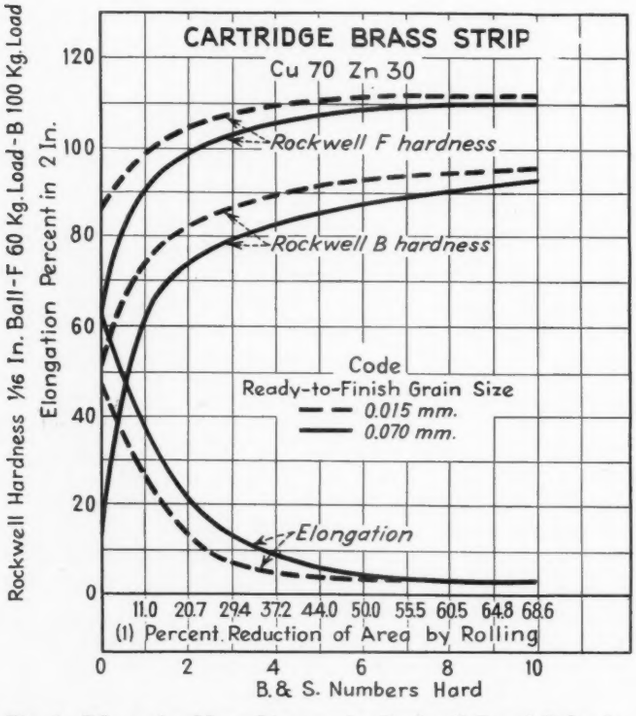

CARTRIDGE BRASS STRIP
Cu 70 Zn 30
Rockwell F hardness
Rockwell B hardness
Elongation
Code
Ready-to-Finish Grain Size
0.015 mm.
0.070 mm.
Rockwell Hardness 1/16 In. Ball-F 60 Kg. Load-B 100 Kg. Load
Elongation Percent in 2 In.
11.0 20.7 29.4 37.2 44.0 50.0 55.5 60.5 64.8 68.6
(1) Percent Reduction of Area by Rolling
B. & S. Numbers Hard

Fig. 1—Effect of cold working on the Rockwell F and B hardness and percentage elongation of cartridge brass strip having two different ready-to-finish grain sizes

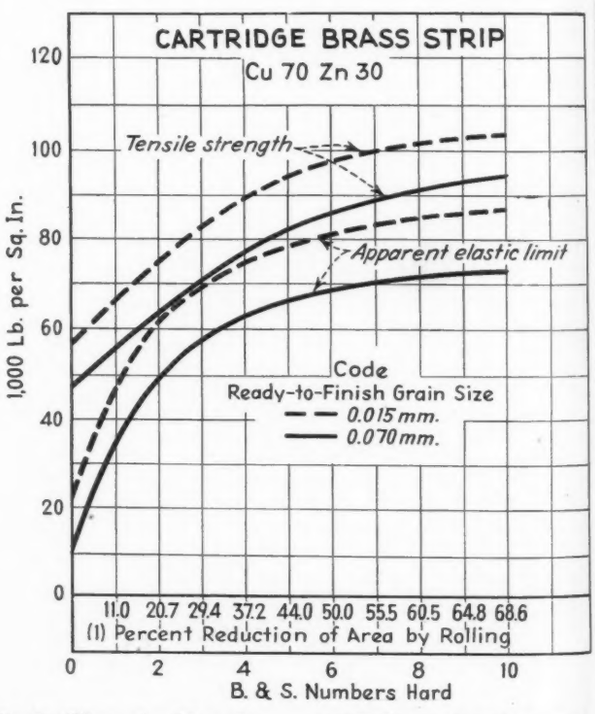


Fig. 2—Effect of cold working on tensile strength and apparent elastic limit of cartridge brass strip. Ready-to-finish grain size has considerable effect on these properties

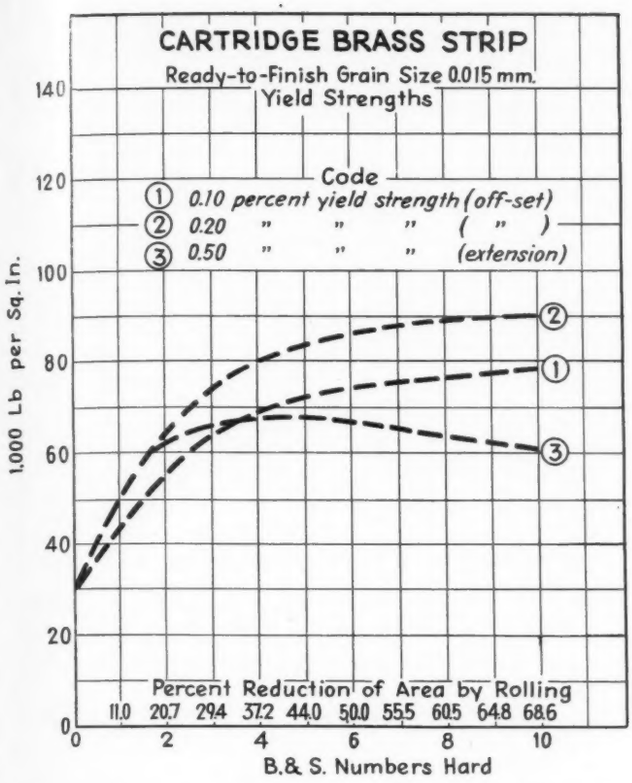

CARTRIDGE BRASS STRIP
Ready-to-Finish Grain Size 0.015 mm.
Yield Strengths
Code
① 0.10 percent yield strength (off-set)
② 0.20 " " " (")
③ 0.50 " " " (extension)
1,000 Lb per Sq. In.
Percent Reduction of Area by Rolling
11.0 20.7 29.4 37.2 44.0 50.0 55.5 60.5 64.8 68.6
B.& S. Numbers Hard

Fig. 3—Effect of cold working on yield strength of cartridge brass strip having a ready-to-finish grain size of 0.015 mm. A comparison with Fig. 8 shows the effect of differences in ready-to-finish grain size

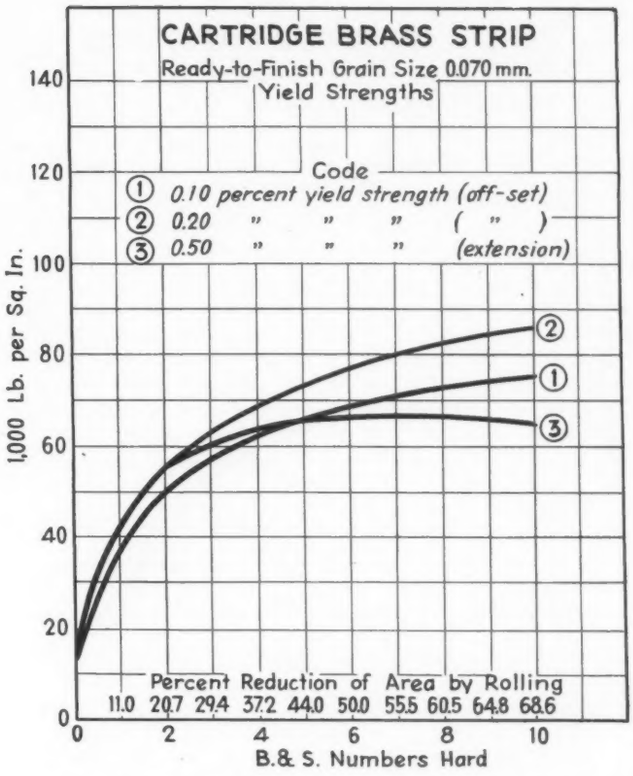

CARTRIDGE BRASS STRIP
Ready-to-Finish Grain Size 0.070 mm.
Yield Strengths
Code
① 0.10 percent yield strength (off-set)
② 0.20 " " " (")
③ 0.50 " " " (extension)
1,000 Lb. per Sq. In.
Percent Reduction of Area by Rolling
11.0 20.7 29.4 37.2 44.0 50.0 55.5 60.5 64.8 68.6
B.& S. Numbers Hard

Fig. 4—Effect of cold working on yield strength of cartridge brass strip having a ready-to-finish grain size of 0.070 mm. A comparison with Fig. 7 shows the effect of difference in ready-to-finish grain size

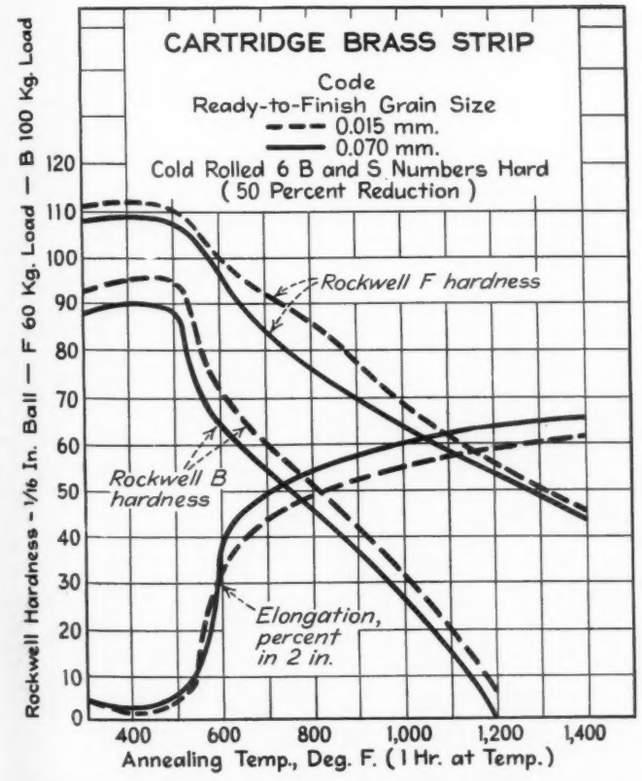

CARTRIDGE BRASS STRIP
Code
Ready-to-Finish Grain Size
0.015 mm.
0.070 mm.
Cold Rolled 6 B and S Numbers Hard
(50 Percent Reduction)
Rockwell Hardness - 1/16 In. Ball — F 60 Kg. Load — B 100 Kg. Load
Rockwell F hardness
Rockwell B hardness
Elongation, percent in 2 in.
Annealing Temp., Deg. F. (1 Hr. at Temp.)

Fig. 5—Rockwell F and B hardness and percentage elongation of cartridge brass strip as affected by ready-to-finish grain size and by annealing after cold rolling to 6 B. & S. numbers hard

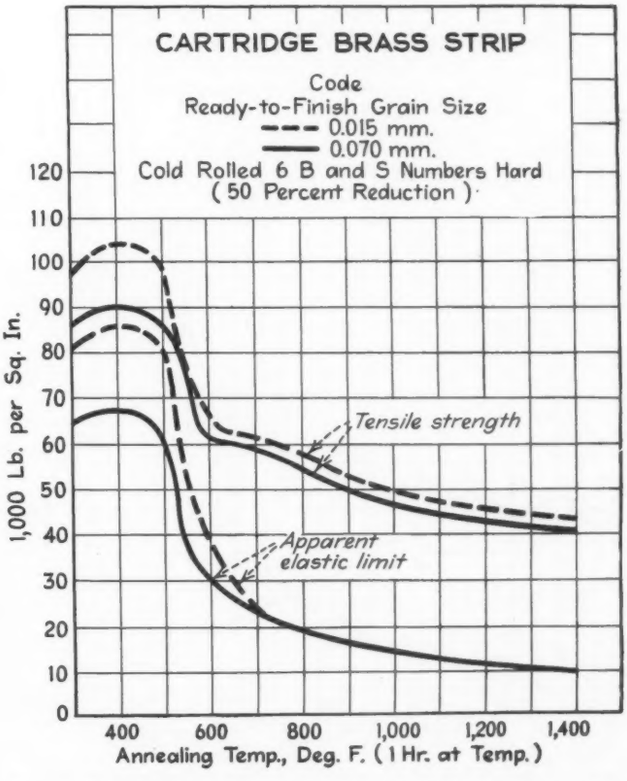

CARTRIDGE BRASS STRIP
Code
Ready-to-Finish Grain Size
0.015 mm.
0.070 mm.
Cold Rolled 6 B and S Numbers Hard
(50 Percent Reduction)
1,000 Lb. per Sq. In.
Tensile strength
Apparent elastic limit
Annealing Temp., Deg. F. (1 Hr. at Temp.)

Fig. 6—Tensile strength and apparent elastic limit of cartridge brass strip as affected by ready-to-finish grain size and by annealing after cold rolling to 6 B. & S. numbers hard

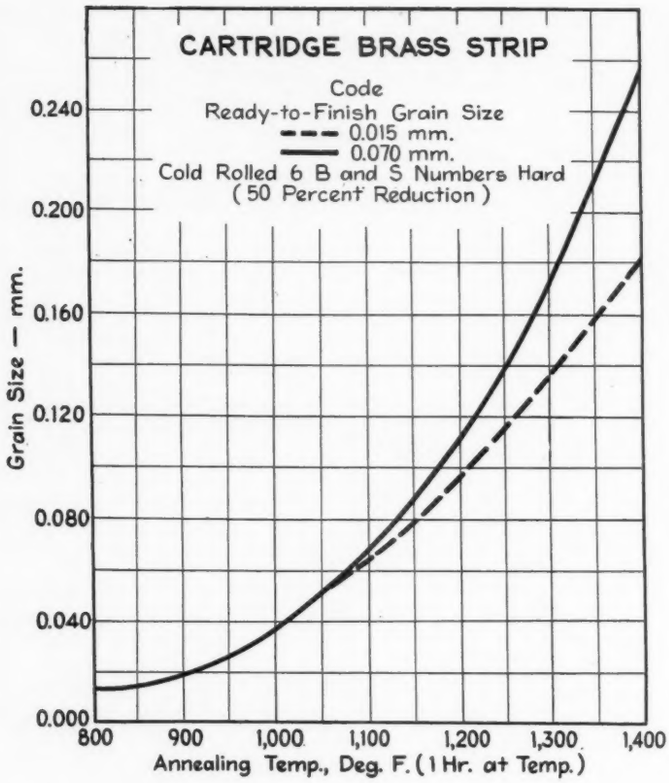


Fig. 7—Grain growth of cartridge brass strip as affected by ready-to-finish grain size and by annealing after cold rolling to 6 B. & S. numbers hard

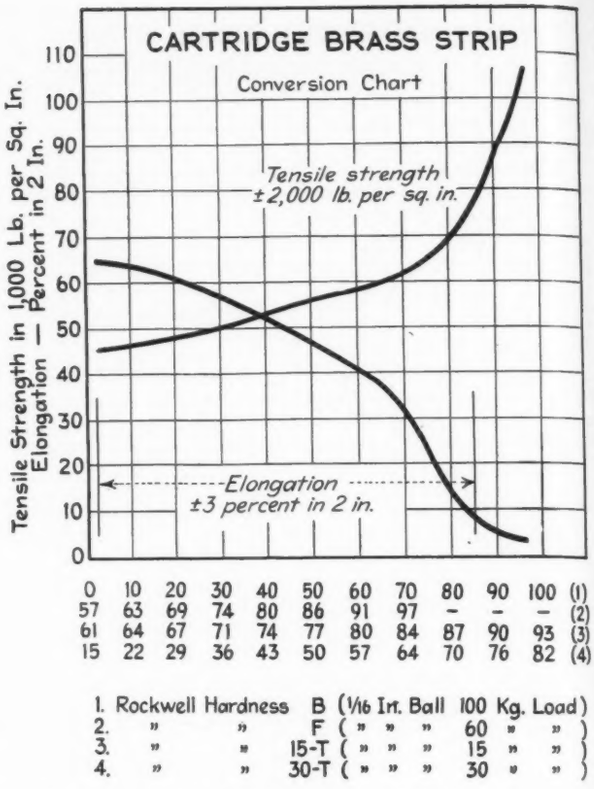

CARTRIDGE BRASS STRIP
Conversion Chart
Tensile Strength in 1,000 Lb. per Sq. In.
Elongation — Percent in 2 In.
Tensile strength
±2,000 lb. per sq. in.
Elongation
±3 percent in 2 in.
110
100
90
80
70
60
50
40
30
20
10
0
0 10 20 30 40 50 60 70 80 90 100 (1)
57 63 69 74 80 86 91 97 – – – (2)
61 64 67 71 74 77 80 84 87 90 93 (3)
15 22 29 36 43 50 57 64 70 76 82 (4)
1. Rockwell Hardness B (1/16 In. Ball 100 Kg. Load)
2. " " F (" " " 60 " ")
3. " " 15-T (" " " 15 " ")
4. " " 30-T (" " " 30 " ")

Fig. 8—Approximate tensile strength and percentage elongation can be determined when only hardness is known. Accuracy is within the indicated limits

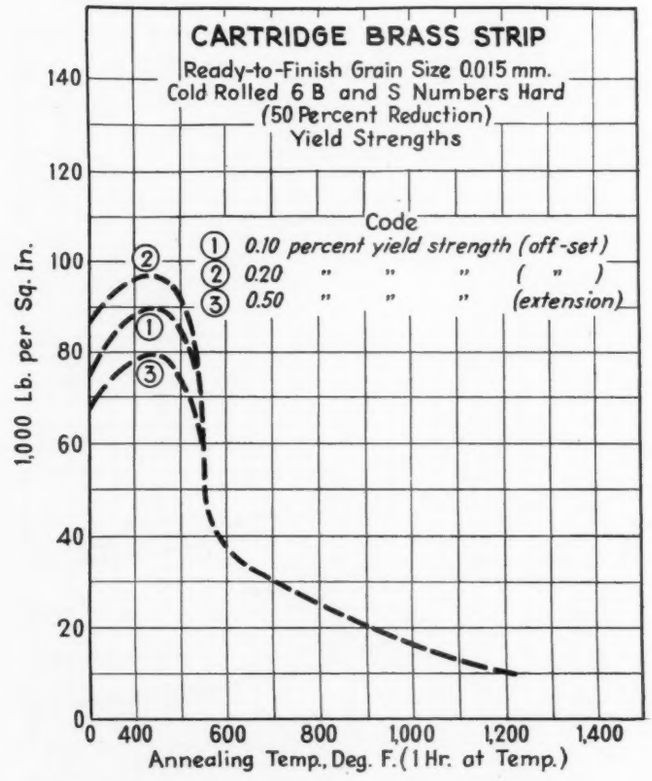


Fig. 9—Yield strength of cartridge brass strip having a ready-to-finish grain sizs of 0.015 mm. as affected by annealing after cold rolling to 6 B. & S. numbers hard. Compare with Fig. 10 for the effect of difference in ready-to-finish grain size

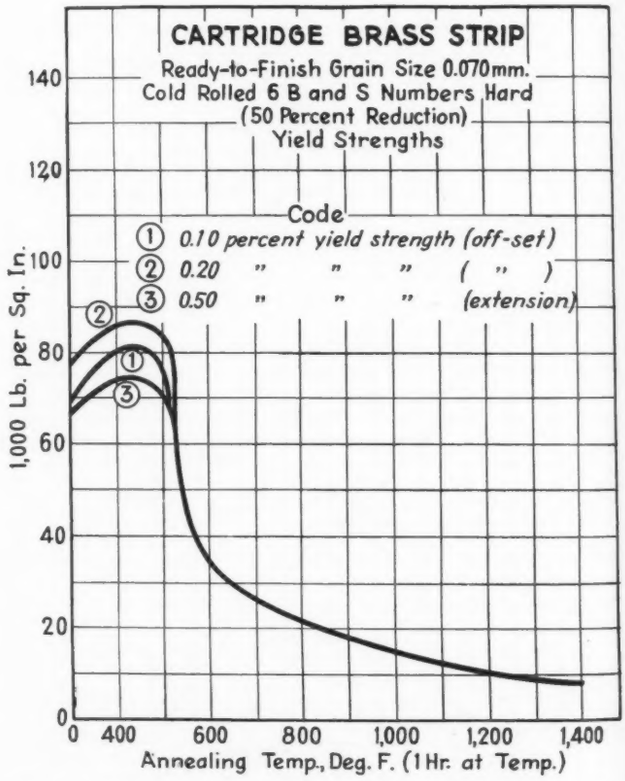


Fig. 10—Yield strength of cartridge brass strip having a ready-to-finish grain size of 0.070 mm. as affected by annealing after cold rolling to 6 B. & S. numbers hard. Compare with Fig. 9 for the effect of difference in ready-to-finish grain size

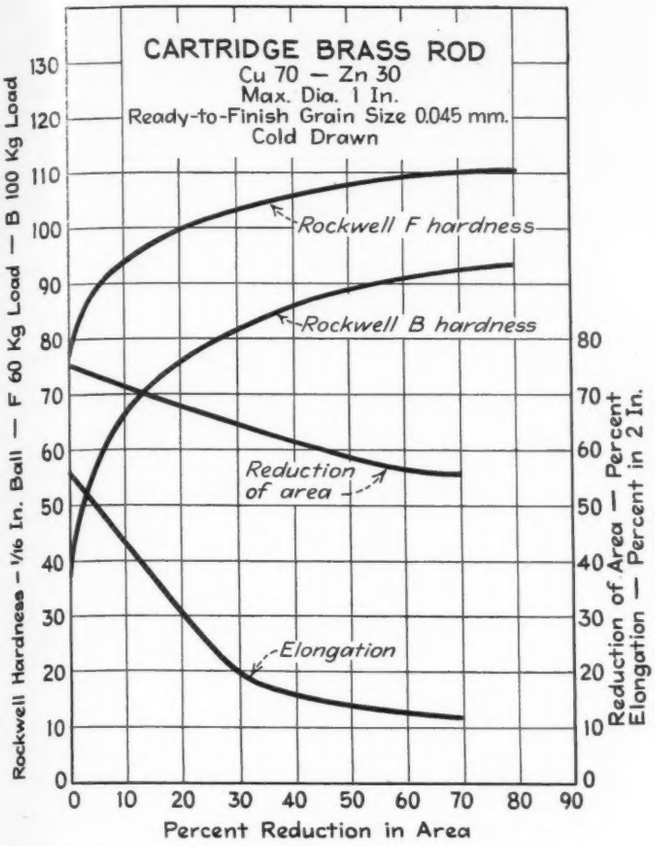

CARTRIDGE BRASS ROD
Cu 70 — Zn 30
Max. Dia. 1 In.
Ready-to-Finish Grain Size 0.045 mm.
Cold Drawn
Rockwell F hardness
Rockwell B hardness
Reduction of area
Elongation
Rockwell Hardness — 1/16 In. Ball — F 60 Kg Load — B 100 Kg Load
Reduction of Area — Percent Elongation — Percent in 2 In.
Percent Reduction in Area

Fig. 11—Effect of cold working on hardness, reduction of area, and percentage elongation of cartridge brass

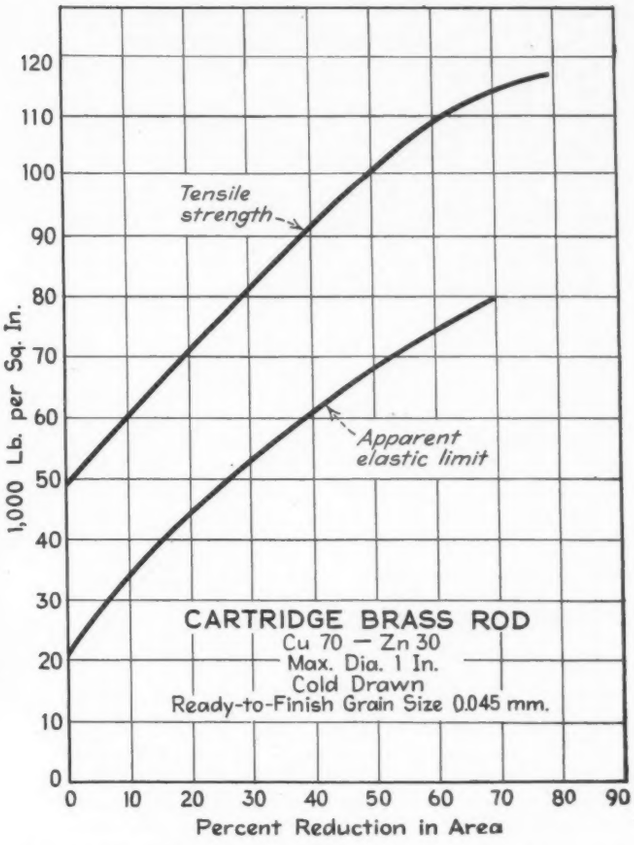


Fig. 12—Effect of cold working on tensile strength and apparent elastic limit of cartridge brass rod

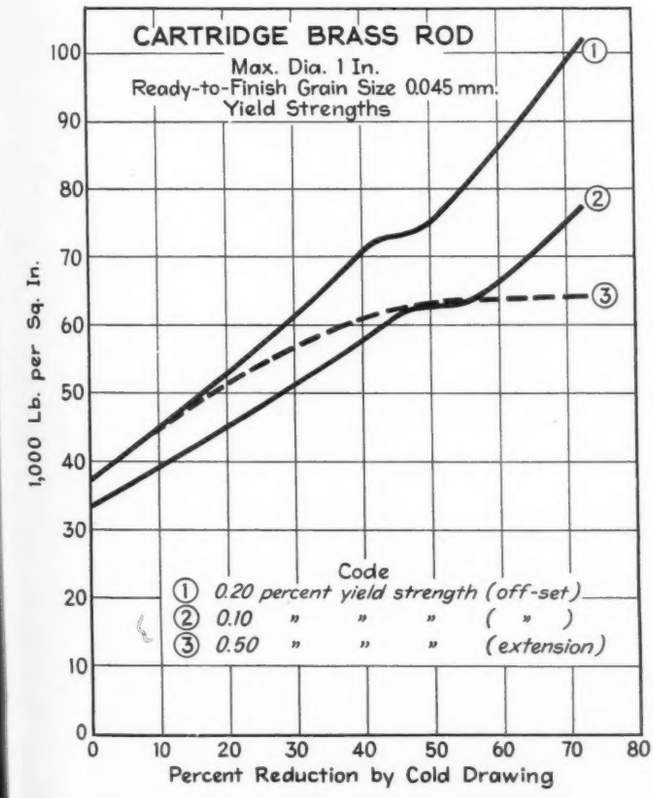

CARTRIDGE BRASS ROD
Max. Dia. 1 In.
Ready-to-Finish Grain Size 0.045 mm.
Yield Strengths
Code
① 0.20 percent yield strength (off-set)
② 0.10 " " " (")
③ 0.50 " " " (extension)
1,000 Lb. per Sq. In.
Percent Reduction by Cold Drawing

Fig. 13—Effect of cold working on yield strength of cartridge brass rod as indicated by three methods

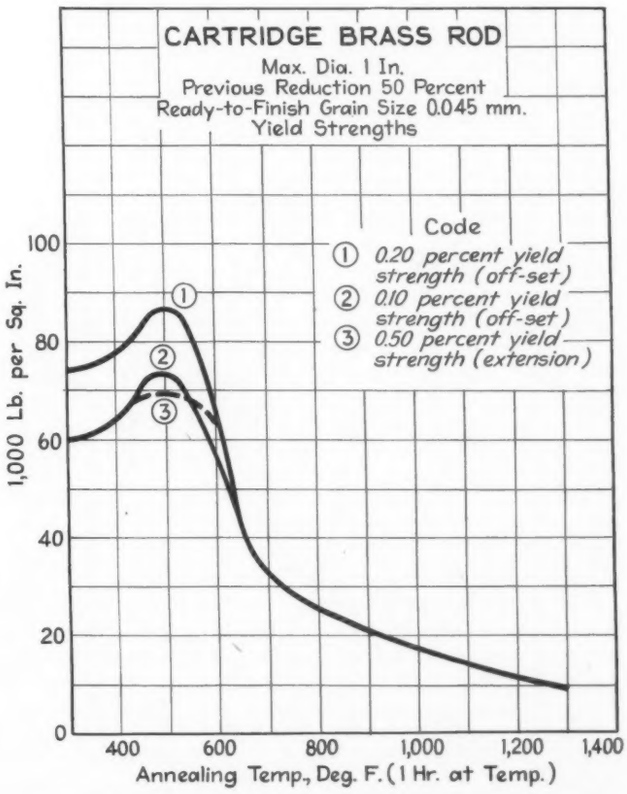

CARTRIDGE BRASS ROD
Max. Dia. 1 In.
Previous Reduction 50 Percent
Ready-to-Finish Grain Size 0.045 mm.
Yield Strengths
Code
① 0.20 percent yield strength (off-set)
② 0.10 percent yield strength (off-set)
③ 0.50 percent yield strength (extension)
1,000 Lb. per Sq. In.
Annealing Temp., Deg. F. (1 Hr. at Temp.)

Fig. 14—Effect of annealing on yield strength of cartridge brass rod after cold working to 50 percent reduction in area

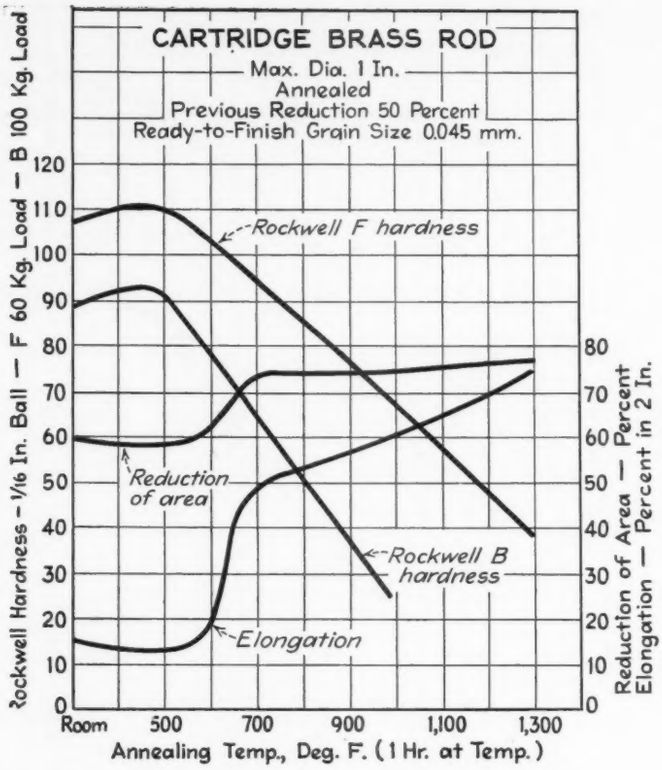

CARTRIDGE BRASS ROD
Max. Dia. 1 In.
Annealed
Previous Reduction 50 Percent
Ready-to-Finish Grain Size 0.045 mm.
Rockwell F hardness
Reduction of area
Rockwell B hardness
Elongation
Rockwell Hardness — 1/16 In. Ball — F 60 Kg. Load — B 100 Kg. Load
Reduction of Area — Percent
Elongation — Percent in 2 In.
Room 500 700 900 1,100 1,300
Annealing Temp., Deg. F. (1 Hr. at Temp.)

Fig. 15—Effect of annealing on hardness, percentage reduction of area, and percentage elongation of cartridge brass rod

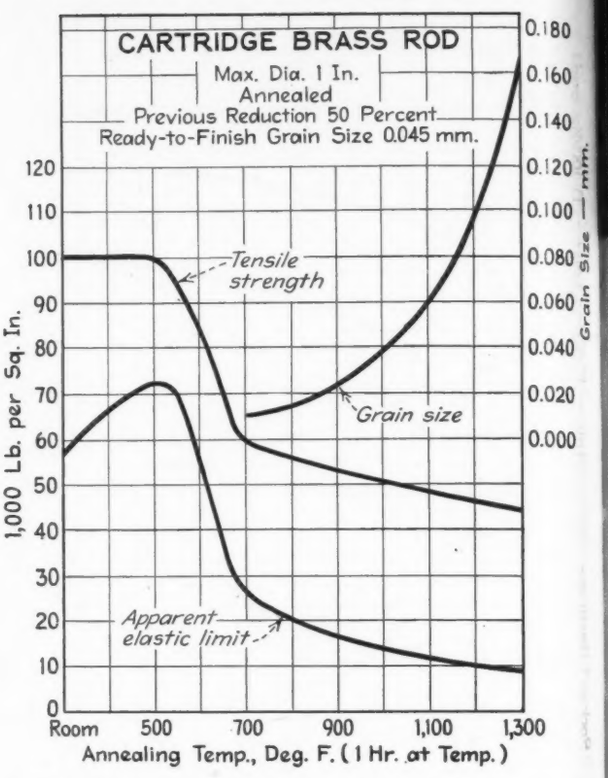


Fig. 16—Effect of annealing on tensile strength, apparent elastic limit, and grain growth of cartridge brass rod

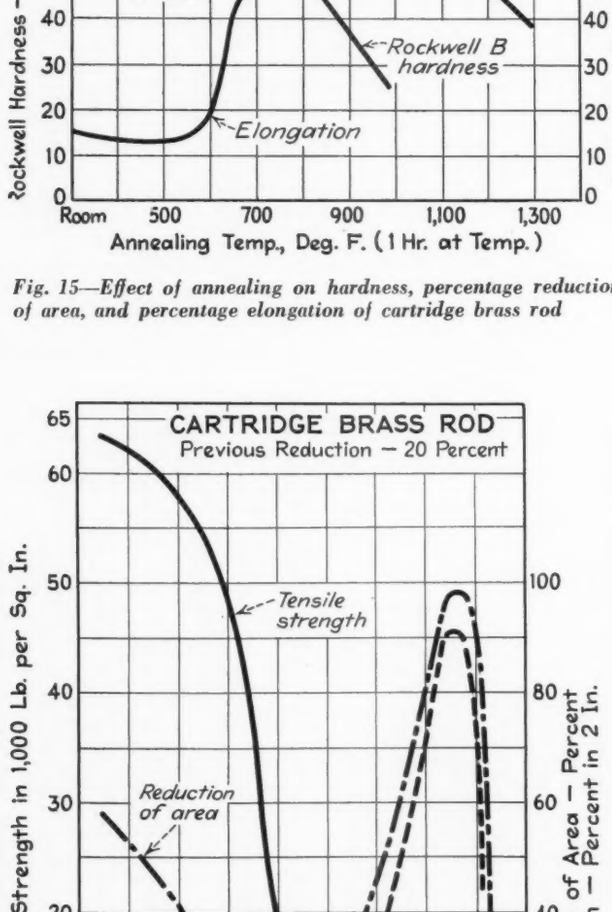

CARTRIDGE BRASS ROD
Previous Reduction — 20 Percent
Tensile strength
Reduction of area
Elongation
Tensile Strength in 1,000 Lb. per Sq. In.
Reduction of Area — Percent
Elongation — Percent in 2 In.
0 400 800 1,200 1,600
Annealing Temp., Deg. F. (1 Hr. at Temp.)

Fig. 17—Effect of annealing on tensile strength, elongation and reduction of area of cartridge brass rod after cold working to 20 percent reduction in area

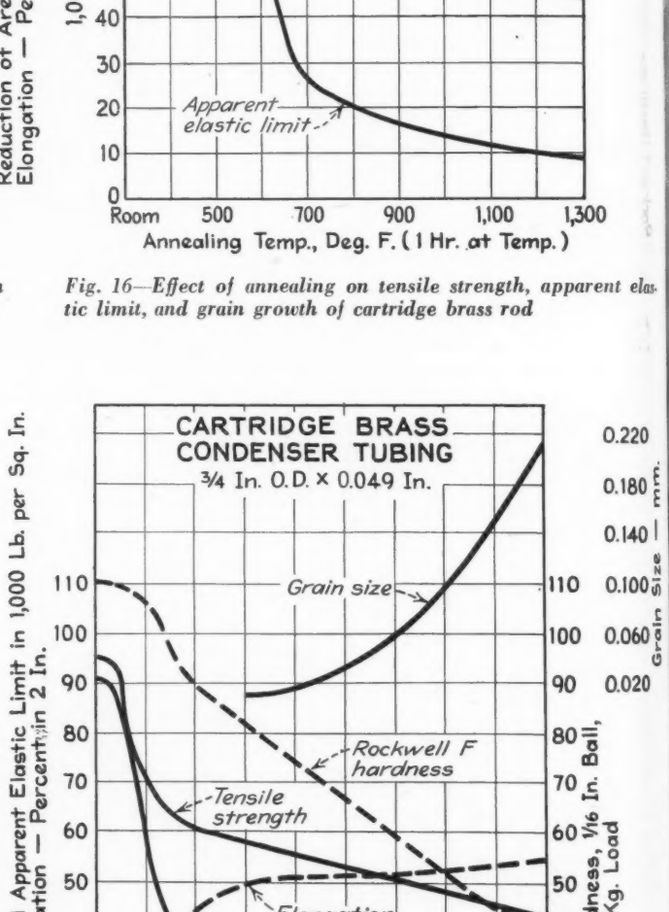

CARTRIDGE BRASS CONDENSER TUBING
3/4 In. O.D. x 0.049 In.
Grain size
Rockwell F hardness
Tensile strength
Elongation
Apparent elastic limit
Tensile Strength and Apparent Elastic Limit in 1,000 Lb. per Sq. In.
Elongation — Percent in 2 In.
Grain Size — mm.
Rockwell Hardness, 1/16 In. Ball, 60 Kg. Load
400 600 800 1,000 1,200
Annealing Temp., Deg. F. (1 Hr. at Temp.)

Fig. 18—Effect of annealing on physical properties of cartridge brass condenser tubing after cold working to 65 percent reduction of area from a ready-to-finish grain size of 0.050 mm.

Question and Comment

Plastics in Defense

1ST LT. D. W. HOPPOCK
Ordnance Department, U. S. Army

As the cavernous appetite of the defense program for engineering materials of all kinds exhaust our formerly adequate supplies of aluminum, magnesium, steel, and other metals, what can be looked for from the relatively new group of synthetic materials loosely termed, "plastics?" Have plastics, the modern material, a place in modern warfare?

Plastics now have some, although not many, military uses. In warplanes, plastics are used for instrument panels, tail empennages, rear gunner's turrets, and instrument parts. Complete vision, streamlined contours and protection from high winds is provided by the plastic glass used in airplanes being made for both our own Air Force and that of Britain. This plastic is relatively shatterproof, clear and has less than half the weight of glass. This latter feature allows for extra gas and "payload."

Plastic Fuselages Not Ready

Plastic fuselages for airplanes, which offer the alluring possibility of rapid production when perfected, are far from military use. Strictly speaking, fuselages made to date are not "plastic." They are plywood bonded with synthetic resin. Several small commercial models have been made, but this war will, it is hoped, be history before this method is perfected to meet the tremendous strength requirements of the combat plane fuselage.

The Signal Corps, responsible for the supply and operation of all Army communications, uses plastics in a manner similar to commercial practice for parts of telephones, microphones, compasses, instruments and dynamotors.

The Chemical Warfare Service uses cellulose acetate pieces in its gas masks. Their flexibility aids talking by wearers.

The Quartermaster Corps, which is responsible for procuring most of the "non-fighting" items for the soldier, from beans to trucks, is using plastics for knife handles, combs, buttons, inkwells, and truck accessories. These materials, like most other Army equipment, must meet rigid Army specifications of resistance to heat, cold, perspiration, and steam. Our Army may have to operate in Arctic cold 40 deg. F. below zero, or under conditions 180 deg. above!

Army Is Studying Plastics

The Army is now embarked upon an intensive program to determine where plastics can be used as substitutes for critical and strategic materials. Particularly are the Ordnance and Quartermaster Departments attempting to find substitutes for use of aluminum and magnesium which are desperately needed by the Air Corps in the ever expanding plane manufacturing program. In this they are aided by the Office of Production Management.

Outside of the specialized fields of aviation and shipbuilding, the product engineer is interested principally in ordnance items, contracts for which are being spread throughout the nation's industry. Army ordnance engineers have been aware of plastics for many years. Under pressure of the present shortage of aluminum, which is used for fuse parts, windshields for armor piercing projectiles and other items where its high strength and light weight have ballistic or other important military advantages, Ordnance officials have redoubled their efforts to find substitutes among the plastics.

Phenolics Best for Ordnance

Probably the best plastics for ordnance use, according to Lt. Col. K. F. Adamson of the Ordnance Department, are the phenolic resins. These seem to have the strength, dimensional stability and resistance to heat and cold to meet the specifications for ordnance items, such as false ogives on shells and bombs, and low velocity fuse parts. Plastic parts have not yet been standardized for any of these items, and will not be until after extensive tests.

It must be remembered that ordnance ammunition items must withstand the tremendous acceleration stress of a projectile moving from rest to velocities approaching 3,000 ft. per sec. in gun barrels only 4 ft. long. Likewise, ammunition components must meet rotational stresses induced by a rotational acceleration from zero to 10,000 ft. per sec. during the same brief barrel travel.

The best bet for the use of plastics in ammunition appears to be as windshields on projectiles and bombs (which have no operational function) and as fuse bodies for the low velocity trench mortar shells.

Another advantage for the use of plastics to replace fuse and other ammunition components is the release of metal working machine tools, for the end of the machine tool bottleneck is not yet in sight.

The Ordnance Department has adopted the use of plastic bayonet scabbards, and grips and handles for machine guns and pistols. It is likely that plastics will, in the future, be adopted for miscellaneous items in and on tanks and artillery, such as ammunition racks, gunners seats, foot pedals, cases, dials and knobs on fire control instruments.

A plastics engineer could make himself a name within the Army by designing a plastic powder bag for large guns which, like silk, would completely burn up along with the propelling powder. If any residue of the powder bag is left burning in the gun, it is likely not to be completely extinguished by the chamber swab, with disastrous results when the next charge is rammed home.

Another chance for fame and fortune would be to improve the synthetic silks now being tried for parachutes, so that the qualities of the synthetic would equal those of silk for this purpose. The demand for parachutes for air-borne troops threatens to outrun the supply of silk—particularly under the cloud of our present war with Japan.

In the final analysis, fighting material demands the best quality to stand up under the maximum stresses and strains of military use. Cost is a secondary factor when the lives of our soldiers and the safety of our country are at stake. Insofar as ultimate strength and durability are concerned, plastics are still in the class of substitutes for steel and aluminum.

It would, therefore, seem well to look

to civilian products for any great expansion of the use of plastics under the defense program. The beauty which is a common property of plastics is a commercial asset, although frequently a military liability. Also, maximum strength is not generally demanded commercially.

And finally, the most inevitably, some sort of substitute material will *have* to be found for many commercial products, simply because defense needs will have first priority.

Find Minimum Dimensions of This Pipe Joint

To the Editor:

I am confronted with the following problem and would like to have comments from PRODUCT ENGINEERING readers on its solution:

(1) Referring to the sketch, determine for the ring the seating area and the cross-sectional area of the ring.

(2) Determine for the seating member the stresses in the section, and the cross-sectional area required.

The sketch shows a sealing device in use in piping. General dimensions of the members are standardized by a Standardization Committee of the American Petroleum Institute. However, I have occasion to adapt this sealing method to other conditions in which it becomes necessary to make the sections as light as possible. This, of course, necessitates examination of the stresses in the various members, particularly the seating member because it must give sufficient support to seat the ring.

Any comments and ideas for solution of the problem will be welcomed.

—J. EDWARD LOEFFLER, JR.
Red Devil Burner Corporation

Springback Beyond Proportional Limit

To the Editor:

There is a rather serious approximation, which apparently has been overlooked, in the theory for "Determining Springback" as developed in the October and November series of articles by R. G. Sturm and B. J. Fletcher. The flexure formula, $f_1 = Mc_1/I$ is valid only for bending within the proportional limit. For bending beyond the proportional limit as is done in this problem, the formula should read $f_1 < Mc_1/I$ and the final formula should read

$$\frac{1}{R_1} < \frac{1}{R_2} + \frac{M}{E_r I}$$

where

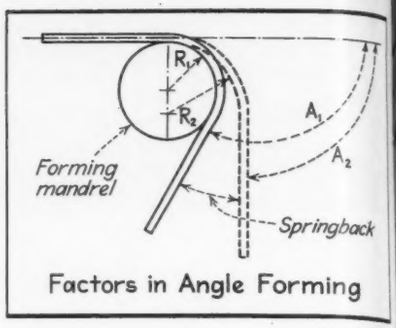
R_1 = radius of the die
R_2 = final radius of the beam
M = total internal bending moment when beam is against the die
I = Moment of inertia of the cross-sectional area
E_r = Ratio of the stress relieved to the strain relieved in the extreme fiber when the beam is released from the forming die—very nearly equal to the ordinary modulus of elasticity

From this inequality one would expect observed values of R_2 to be less than calculated values—that is the die would have too sharp a radius. In view of this, painstaking calculation of M would seem a waste of time. Experimental data demonstrating the accuracy of the author's formula would be interesting to see.

We have used a similar formula,

$$1/R_1 = 1/R_2 + 1/R_o,$$

in calculating dies for forming a spring wire. In this formula R is determined by a trial forming operation and is nearly constant over wide ranges. Thus



Factors in Angle Forming

in forming 0.006 in. dia. spring wire R_1 increases from 0.167 in. to 0.178 in. as R_2 varies from 0.023 in. to 0.100 in. R_1 varies more rapidly as R_2 becomes large.

To calculate angles we use the formulas

$$A_1 = A_2 \frac{R_2}{R_1} \text{ or } A_1 = A_2 \frac{R_o}{R_o - R_1}$$

where the angles are as indicated in the sketch.

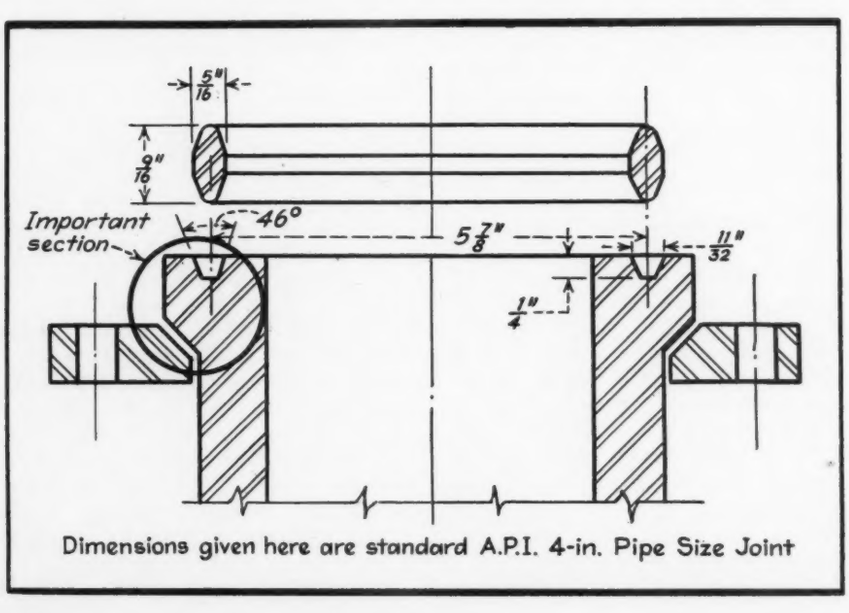
—P. W. CRIST
East Orange, N. J.

To the Editor:

We have considered Mr. Crist's letter carefully and, of course, agree with him wholeheartedly that the formula $f_1 = Mc_1/I$ is valid only for bending within the proportional limit and that for stress beyond the proportional limit is no longer valid, but that f_1 would be less than that indicated by Mc_1/I. However, as we have stated in our paper when the original external bending moment is released the "corresponding *elastic stress release* may be computed by the ordinary flexure formula."

The results of a great many tests on measuring the elastic recovery of strains as the applied stress is released indicate that the returning stress-strain curve is essentially parallel to the original straight-line portion of the stress-strain curve and that for most structural materials such as aluminum alloys, steels and copper, this straight-line relationship continues as the stress passes through zero and changes sign. For information regarding such cyclic stress-strain curves for various materials subjected to plastic deformations in one direction and then released, we refer to the article entitled "Some Stress-Strain Studies of Metals" by R. L. Templin and R. G. Sturm, published in the *Journal of the Aeronautical Sciences*, March 1940. We have found for practically all cases of forming structural members, the error involved in using $f_1 = Mc_1/I$ for the elastic springback is less than the probable error in the stress-strain curve used for the particular material considered because of the inherent variations in material within commercial tolerances.

For the particular problem Mr. Crist



Dimensions given here are standard A.P.I. 4-in. Pipe Size Joint

has mentioned, that of bending spring wire, it is altogether possible that the amount of springback occurring for this material and for the relatively sharp radii used in forming springs was sufficient to exceed the elastic limit of the extreme fibers. If this is the case, then his problem lies outside the scope of our paper and the method he has used in determining an equivalent amount of springback indicated by $1/R_o$ determined experimentally could be used to advantage for problems involving such severe bending.

The authors wish to express appreciation to Mr. Crist for his interest in this problem and for his contribution in pointing out a case in which experimental evidence must be resorted to in order to obtain a solution.

—R. G. STURM
B. J. FLETCHER
Aluminum Research Laboratories
Aluminum Company of America

Toothless Reduction Gear Made in England

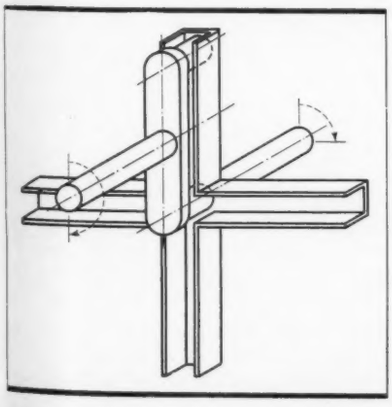
To the Editor:

The toothless reduction gear, information on which was requested in the November number of PRODUCT ENGINEERING, has been manufactured by Burn Transmission Ltd. and Silent Transmissions Ltd., England since the mid-twenties and has been used for marine reduction gears, reduction gears for ventilating fan drives, and similar applications.

The manufacturers supply a drive incorporating a simple but ingenious reversing mechanism which is also gearless. It can also be used as an increasing speed gear.

An efficiency of 98 percent is claimed. To my personal knowledge transmissions handling up to 300 b. hp. have been put into service. In fact a number of these gears are in use in this country.

—G. L. PEARSON
Jacobs Aircraft Engine Company



Errata in Helical Tension Spring Tables

To the Editor:

In my articles "Helical Tension Spring Tables" which were published in the November and December, 1941, numbers (pages 631-632 and 689-692, there are a few errors which I would like to call to the attention of PRODUCT ENGINEERING readers. These corrections should be published in "Question and Comment," and should be noted by every reader who is using or who may sometime make use of the tables.

On page 631, Fig. 1, the formula

$$D_t = \frac{i}{i-1} \text{ should read } D_t = \frac{i}{i-1} S$$

In Table *C* on page 632, the same formula is misprinted again:

$$D_t = \frac{i}{i-l} \times S \text{ should read } D_t = \frac{i}{i-1} S$$

On page 689, in the directions *A*, springs for static load, in item (4) of the solution, the equation

$$l_0 = l\,R\,[R + (1 - T)]$$

should read $l_0 = \dfrac{l\,R}{R + (1 - T)}$

In the directions *C* for spring selection, the given values should be "P_1, i, S, and required l," instead of "P_1, i, l and required P."

Finally, in the solution of directions *C*, item (2) which reads:

"Approximate $R = (l\,D_t) - 1$"

should read "Approximate $R = \dfrac{l}{D_t} - 1$"

—PAUL KLAMP
East Canton, Ohio

[*Editor's Note*—Part III, which concludes Mr. Klamp's series, is published in this issue, pages 59-60.]

Can You Work This One?

H. E. SMITH

This month's problem—

Allocating Nickel

A certain amount of nickel is to be distributed to two companies *A* and *B*. It makes a difference to *A* of 25 lb. whether, in the distribution, he gets 20 percent more nickel than *B* or *B* gets 20 percent more than *A*. How many pounds of nickel are to be divided between the two companies?

Solution to December problem—

This One's a Pipe

The disconsolate plumber in last month's problem had to determine where to put the second bend in the pipe in order to meet the condition shown in Fig. 1. Referring to Fig. 2,

Let

$$l = \text{length } AD = \frac{120-40-x}{2} = AB+BC+CD$$

$$40 - x/2 = \frac{10}{\cos\phi} + 5\tan\phi + 5\left(\frac{\pi}{2} - \phi\right) \quad (1)$$

Also

$$AC = AB + BC = AF/\sin\phi = (AE - EF)/\sin\phi$$

$$= \frac{10}{\cos\phi} + 5\tan\phi =$$

$$\left(30 - \frac{x}{2} - 5\cos\phi\right) / \sin\phi$$

from which

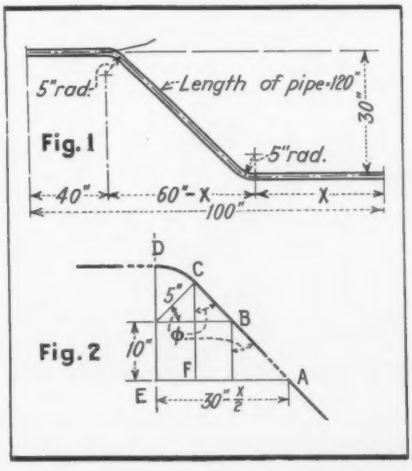
$$10\tan\phi + 5\tan\phi\sin\phi + 5\cos\phi - 30 = -\frac{x}{2} \quad (2)$$

substituting (2) in (1) and reducing

$$f(\phi) = (1 - \sin\phi)\tan\phi - \cos\phi + \phi - \frac{\pi}{2} + 2 = 0 \quad (3)$$

The numerical solution of this equation can be reached by rapid steps to any desired degree of precision by Newton's method of approximation. After three approximation steps, the answer is found to be

$$x = 43.2285 \pm 0.000.1$$



News and Summaries

Materials Standardization Aids Preparation of Purchase Specifications

GENERAL ELECTRIC, like many other large organizations, has set up quality standards for the materials going into the manufacture of its apparatus and merchandise equipment. Because of the thousands of different materials purchased each year, these standards necessarily cover a wide and diversified field. Practically every major group or family of materials is represented from paper, textiles, glass, sand and refractories, to ferrous and non-ferrous metals, chemicals, rubber, fabricated parts and finished.

According to Mr. G. H. Harnden of the Works Laboratory of the General Electric Company at Schenectady, N. Y., standardization of materials is very closely associated with the preparation of purchase specifications. For that matter, before a material may be considered standard, it is necessary to set up reasonable specification requirements which will guarantee the maintenance of quality and workmanship on future shipments. In doing this, commercial specifications of industry are closely scrutinized to ascertain if they may be used in whole or in part. Conferences are arranged with the manufacturers and interested engineering and manufacturing departments. As a result a G. E. standard is proposed around which a purchase specification is prepared which will cover satisfactorily the engineering requirements and guarantee the maintenance of quality of the material without penalizing the manufacturer.

This work is carried on by the Specification Section of the Schenectady Works Laboratory, under the supervision of Mr. Harnden and in conjunction with the Standards Department. The illustration showing the standards to date will indicate the magnitude of the work. This group consists of approximately 1400 G. E. standards, together with their purchase specifications, as well as several hundred specifications on special materials (non-standard). Each month an average of ten new standards are added to this group, while approximately forty specifications covering existing standards are revised to keep them in accordance with changing engineering requirements, revisions in existing commercial standards, and to take advantage of the development of new materials suitable for the application intended.

In addition to the preparation of G. E. standards, there is also the preparation of cross-reference information on government specifications and other nationally recognized standards for the use of engineering and manufacturing departments. (These are not shown in the illustration). In these times of national emergency, every effort is made to co-ordinate G. E. standards with governmental bureau specifications and other nationally recognized standards. One does not realize the magnitude of this co-ordination work, but it entails the careful comparison of approximately 3000 different standards with comparable G. E. standards, and the noting of the differences therein.

The manner in which G. E. disseminates information on its standards throughout its widely separated Works and Manufacturing Departments is novel. Data on a standard material are issued in three different forms, giving different functions only the type of information in which they are interested, as follows:

(a) The purchase specification as described herein is intended for use by the manufacturers and is distributed to them by the Purchasing Department.

(b) The engineering property sheet contains all essential engineering information contained in the purchase specification, as well as other typical data on the material, such as machineability, weldability, corrosion resistance, recommended usage, etc. This sheet is given wide distribution throughout the engineering, drafting and factory departments.

(c) The data for ordering sheet con-

More than 1,400 standards, compiled in these volumes by G. H. Harnden of General Electric (above) form the basis for all G. E. specifications

tains a brief description of the material, indicates the latest edition of the specification, advises the proper wording of orders, and lists the approved sources of supply. This sheet is distributed only to those departments interested in the placing of orders for materials.

With the preparation of a specification standard, a G. E. material designation consisting of a combination of letters and numerals is assigned to it. The numbering classifies the type of material and thereafter in all data sheets, correspondence, etc., the material number of the standard serves to identify the standard and act as a file reference.

New Plastic Molding Process Announced

A NEW PROCESS for molding sheets of almost any thermoplastic material is the important announcement of Walco Plastics of East Orange, N. J. By the Walco process, sheets of thermoplastic material, even cellulose acetate, are molded with a single operation into such objects as radio cabinets, fluorescent lighting fixtures and many other intricate shapes.

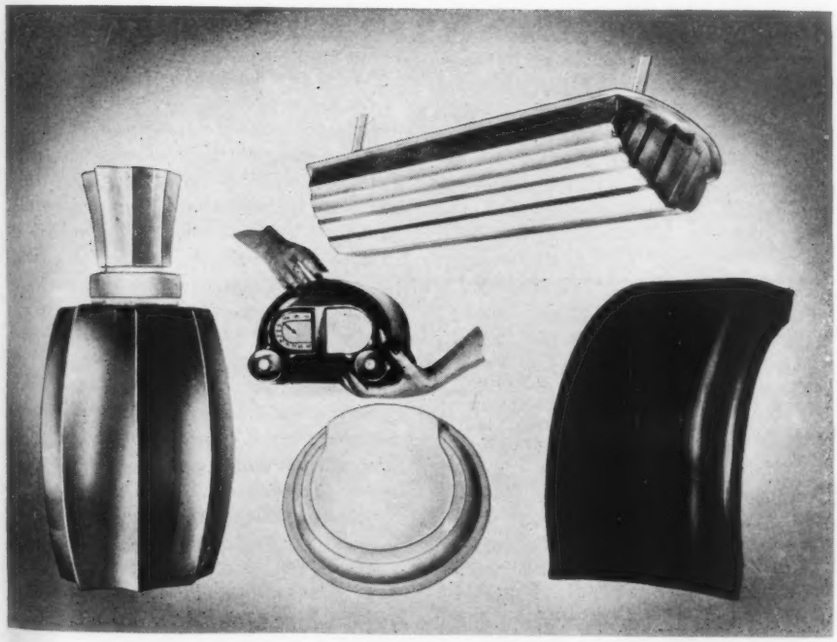
In the past such articles have been produced by the well-established injection and compression molding methods which use molding powders and require costly dies. The incorporation of a new mold construction in the new method, combined with a pretreating process before molding the sheet, give low die cost.

With the Walco process, a single operation between male and female dies transforms a flat sheet of any thermoplastic material into a finished article with as many curves, corners or angles as desired. The article is then said to be ready for shipment unless decorative work is to be applied. Buffing or polishing operations are rarely required.

Another advantage claimed for this process is the ability to mold very thin sheets from 0.005 in. thickness up. This is said to be very much lower than the thinness limit for injection and compression molding so that, while material costs may be higher for sheets, the thinner sections possible will reduce the cost of many items.

Of considerable interest to engineers is the fact that products molded by the Walco process are said to show scarcely any variation in thickness throughout the finished article. A radio cabinet molded to a depth of 6 in. is very little thinner at the point of its extreme depth of mold, in this case its front panel, than at the rear parts of the top and bottom sections. Similarly the walls and curved sections of a seamless candy box are neither thicker nor thinner than the body of the box itself. This uniformity is said to be achieved during the molding process when, under the heat and pressure of the die, an actual flow of material within the sheet takes place. While the technique used to achieve this flow has not been made public, it can be said that the finished article is held to be uniformly thick throughout.

Walco Plastics are now beginning large-scale production of both civilian and defense orders. One of their objectives is claimed to be the relieving of shortages in metals by such products as their one-piece fluorescent lighting fixture, designed to eliminate the necessity for metal brackets and end pieces.



Besides the radio cabinet and luminaire mentioned, a 27 in. high display bottle of cellulose acetate, molded in two sections, and two juke box parts, also made by the Walco Process, are shown

Strategic Materials Table Aids Substitute Selection

THE TABLE BELOW will surprise many people whose ideas on the availability of strategic raw materials have been rather hazy. Latest figures for the production and consumption of and requirements for, the major strategic materials have placed them in the order of decreasing scarcity given below. Beside the names of the materials are their available tonnage in 1941 in percent of steel tonnage, taken as 100 percent. Starting with the most scarce, then, we have

Magnesium	0.02
Aluminum	0.44
Nickel	0.11
Copper	1.97
Cork	0.18
Zinc	1.10
Alloy Steel	7.9
Vanadium	0.002
Tungsten	0.02
Lead	1.14
Molybdenum	0.005
Plastics	0.30
Manganese	0.59
Tin	0.10
Chromium	0.14
Rubber	0.88

Certain additional items may be added to fill out the picture. For example, tonnage of concrete stands at 119% and lumber at 68% of steel. Also, cobalt occupies a scarcity position just below nickel and, between vanadium and tungsten come cadmium, graphite, antimony and pig iron in that order. Mercury deserves a place just ahead of chromium and mica splittings should come just after chromium.

That so few materials have even 1% of the production of steel is the most surprising fact. However, this is no indication of shortage because consumption maintains the same percentage ratio. It is also evident, for example, that substitution of 1 lb. of steel for 1 lb. of aluminum helps the availability of aluminum over 200 times as much as it hurts the availability of steel. Estimates of this type may be helpful in determining replacement materials to be used.

It seems contradictory that all the least scarce items from manganese down are almost completely dependent on overseas shipments. The answer is that increased imports and careful allocations have built stock piles of such dimensions that these items are at present among the least scarce of strategic

materials. Such imported materials as cobalt, cork and tungsten, however, have reached no such favorable position as yet.

Choices of possible substitute materials may be well worth reconsidering in the light of such a table as this.

Defense Production Reaches Bureau of Standards

THE EXTENT to which gages used in industry have been sent to the Bureau of Standards for checking has increased directly with the rise in production for national defense. Requests for calibration are now coming in at the rate of 800 a month.

The tolerance of some machine work requires the precision gage of the shop to be correct within one or two hundred-thousandths of an inch. This, in turn, requires that the secondary or working standards used in the laboratory be correct to within millionths of an inch.

In earlier years the end standards of the Bureau were calibrated with the accepted international line standards derived from the meter. These methods, requiring the use of microscopes, were subject to a wider margin of error than are permitted by the close tolerances required in modern mass production.

In more recent years the lengths of standard light waves, which are invariable, have been used as primary standards. This method is based upon the standard wavelength of the red line of cadmium. Within the length of the standard meter there are more than a million and one-half wavelengths of light.

A ruling machine developed by the bureau for graduating meter bars in terms of light waves is now in regular use and progress has been made on similar equipment for stepping off decimeter and shorter scales.

Meter bars produced with this equipment differ from the approved international standard by less than two parts in 10,000,000. The diamond cutting tool which does the ruling must be sharpened to one hundred-thousandth of an inch.

Magnesium From Ocean Wins Award

MAN'S first successful commercial production of any material from the ocean was rewarded recently with the "Award for Chemical Engineering Achievement" presented biennially by the magazine "Chemical and Metallurgical Engineering." For the successful development of its process for obtaining metallic magnesium from seawater the Award was made to the Dow Chemical Company.

Culminating years of research and experimentation, production at the new Freeport, Texas, plant began on Jan. 21, 1941. Here some 300,000,000 gallons of water daily are mixed with lime obtained from oyster shells dredged from the bottom of Galveston Bay. The resultant magnesium hydroxide precipitate is then filtered, dried and caked. The cakes are then dissolved in a hydrochloric acid solution to give magnesum chloride in liquid form. This liquid is concentrated until only filtered, crystallized magnesium chloride remains and this material, in molten state, is used to charge the electrolytic cells, each of which can produce about 1,000 lb. of metal a day with an average purity of better than 99.8 percent.

The Dow Company's magnesium production for 1941 is said to total 54,000,000 lb. but defense demands are expected to raise this to 125,000,000 lb. for next year, counting Dow plants and government plants run by Dow.

Do You Know That—

Egyptian ladies in 900 B.C. carried vanity cases made of iron which was almost a precious metal in those days. (1)

The steel industry, biggest user of scrap, makes a good share of its own scrap since only 70 percent of a steel ingot becomes finished steel. (2)

"York Plan" Sponsor Receives Award

ON DEC. 3, the American Society of Refrigerating Engineers, convening for its annual meeting at St. Louis, Mo., presented its Distinguished Service Award to Mr. William S. Shipley, one of its past presidents, in recognition of his leadership and outstanding effort in developing and bringing into successful use the "York Plan," a cooperative plan for coordinating the community's civic and industrial activities in the interest of the National Defense Program. Mr. Shipley is chairman of the board of York Ice Machinery Corp., chairman of the Defense Committee of the Manufacturers Association of York, and chairman of Region No. 10 of the Pennsylvania Div. of Contract Distribution of the OPM.

The "York Plan" was created by the Defense Committee of the Manufacturers Association of York. This committee was appointed in July 1940 to study the problems which were arising at York as a result of the expanding defense program, and to investigate not only their effect on the community but how the community as a unit could best function. Out of this study came the "York Plan" which has been called the outstanding plan for cooperative activity and has been adopted as the model for cooperative community activity in the interest of National Defense.

Meetings

Society of Automotive Engineers—Annual Meeting and Engineering Display, Book Cadillac Hotel, Detroit, Mich., Jan. 12-16, 1942. John A. C. Warner secretary, 29 West 39th St., New York, N. Y.

American Society of Heating and Ventilating Engineers—Annual Meeting and 7th International Exposition, Commercial Museum, Philadelphia, Pa., Jan. 26-30, 1942. Charles F. Roth, manager, Grand Central Palace, New York, N. Y.

Inventors' Contributions Aid Defense

DESCRIBING THE WORK of the National Investors' Council of which he is chief engineer, Col. L. B. Lent told the American Society of Mechanical Engineers on Dec. 3 in New York City, that some revolutionary new weapons submitted to the council are now under test and development. "Obviously, the nature of these cannot be disclosed," Col. Lent added, "but about 40 percent are in the general field of ordnance, which includes all kinds of guns and ammunition and also tanks, amphibians and fire-control devices; about 20 percent are in the field of aircraft, including power plants and flying equipment and the remaining 40 percent encompass all other phases of warfare. A relatively large number pertain to geometric and optical instruments and to radio and other electrical devices."

"The number of devices and ideas which are of potential value is quite surprising and indeed most encouraging. Many suggestions are, of course, most amusing. However, the daily consideration of these cases brings a growing conviction of the need of a larger percentage of ideas coming from those who know their subject."

ENGINEERING IN WASHINGTON

McGRAW-HILL WASHINGTON BUREAU, *PAUL WOOTON, CHIEF*

Engineers against Japan have all the advantage, though, as the President said, at the outset, all the news was bad. The military experts here were startled by the effectiveness of Japan's attack. Everybody believed, as everybody said, that the little yellow men had poor airplanes which they didn't know how to fly very well. Regardless of what happened, the best obtainable information shows precisely that to be true. Nippon's brilliant success was due to (1) audacity; (2) Nazi coaching and direct aid; and (3) American inexperience.

Total air forces of Japan's Army and Navy combined is something less than 5,000 planes. Production rate is about 250 a month, as compared with present U. S. rate 2,300 a month—a rate which will increase to 3,000 early in 1942. Apparently none of Nippon's fighter planes have retractable landing gear; they are all still in the wheel-pants stage of development. One of two of their bombers look up to standard. The fastest ship in the country, according to a recent study by Aviation Magazine, was rated at 310 m.p.h. Japan has no four-engined bombers at all. The four-engined planes that took part in the attack on Pearl Harbor were German Focke-Wulfs, probably flown by Germans. It should be noted that the total ship-based air arm of the Japanese Navy is about 250 planes.

Nearly all plane design in Japan is copied from imported machines. Naturally, no country will export their latest designs, so Japan's stuff is old when they start work on it. Not even the Germans have given them latest developments. Incidentally, Germany is behind the combined production of the United States and Britain now, and will not be able to give Japan any. Delivery would be a difficult problem, too. The Nippons have followed Italian design, more than any other. A few years back they bought the big Douglas DC-4, which proved too large to suit transport operators, and the production model was reduced in size. Obviously Japan wanted to copy the Douglas. Later on, they crashed it, which may be why they never made a replica.

At the start of this war, we were even up with Japan on carriers—seven apiece. Of course, many of our merchant ships are being built for conversion And, if the Nazis force collaboration of France any farther, we will take the Normandie and convert her. Brightest spot in the seven to seven ratio with Japan is that the Nippon carriers are only half the size of ours, carrying average 40 planes to our 80.

Startling developments, now being worked on by the Air Corps and by the National Advisory Committee for Aeronautics, may have a revolutionary effect on air war. Whole new fields of design for aircraft and accessories are being investigated with amazing results. Japan, noted for her ability to copy, is likely to fall behind this country more and more, (except for what she can get from the Nazis) now that all these developments have become super-secret.

Some German dive bombers have been equipped with quick-dumping gas tanks, to prevent death by fire of crew in forced landings as a result of enemy action. The tank has a vertical standpipe reaching almost to the bottom, which comes out the top and is carried back to the tail of the plane. In case of emergency the pilot opens a valve admitting air pressure from the superchargers into the gas tanks, which empties them quickly.

A steel airplane is being designed by a committee for Reconstruction Finance Corporation. It is a freight carrier, and is wanted to take the place of the high-lift German Junkers JU-52 in South America where RFC has the job of driving the Nazis out of the airline business.

The ship, nearing completion on paper, is a high-wing monoplane with two engines, a rugged fuselage with big freight hatches, and four-wheel landing gear. They call it a flying freight car. Stainless steel is being specified for the entire air frame, including wing stubs; wings to be wood, some aluminum and fabric. When we asked some top-notch Government authorities why, if steel planes *can* be built, they *aren't* being built, they replied with a shrug that it's a matter of habit. Engineers just get used to working in terms of aluminum, and they don't like to change. Some of them said that a given airplane weighs about the same in steel as it does in aluminum. Nowadays, however, with stainless steel the only type that can be used in planes and nickel almost scarcer than aluminum, designers have to stick to aluminum.

Mobile laundry units are being ordered by quartermaster. Twenty-one will be built by the U. S. Hoffman Machinery Corporation, and sixteen by the American Laundry Machinery Company. Units have their own boilers and power plants and are designed to pump water from any available source. Several test units were run for some time before final design.

First "Liberty" EC-2 engine was completed recently by the Harrison Works of Worthington Pump & Machinery, which holds a large contract, The engine is a reciprocating three-cylinder triple expansion condensing type, weighing about 150 tons. It delivers 2,500 horsepower. Reciprocating engines were chosen for the emergency ships because facilities for building turbines are all occupied with the C ship program, with Navy, and with power generating equipment. Also, it is easier to find engineers who can operate them.

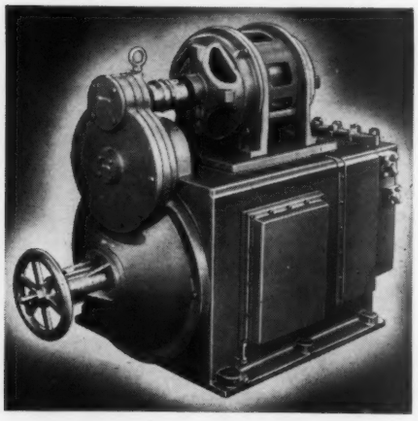
Both fluid and electric drive for tanks are in the works. That is all the Ordnance Office will say. Fluid drive is reported going into light tanks first, under a Cadillac contract. Chrysler is testing the application in its medium tanks. Fluid drive would eliminate most of the heavy transmission gear, and increase maneuverability. It is reported too that automobile engines, installed in multiples of two or four, will replace some airplane engines. Liquid cooling would seem to increase the risk of failure, but Ordnance officers refused to discuss the matter. No information could be found on use of electric drive.

"The year's greatest achievement in aviation," is what General Henry Arnold, Army Air Force Chief, said about metal strip runway for airports. It was tested during Carolina maneuvers. It consists of steel sheets 10 ft. long and 15 in. wide, hooked together to form a tight, firm landing surface. The steel sheet is punched out for lightness and corrugated. During the maneuvers, 75 soldiers laid a foot of 100 ft. wide runway per minute—or 50 hours to lay a complete 3,000 ft. runway.

New Materials and Parts

Variable Delivery Pump

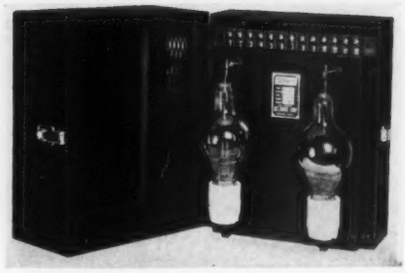
This variable delivery, high-pressure pump recently developed provides a range of flow from 0 to 6 g.p.m. at 5,000 lb, per sq. in. pressure. A new driving member trunnioned on the drive shaft makes this possible. The angle of this member can be varied while the pump is running to produce a corresponding stepless change in plunger stroke from zero to full 4-in. stroke. Extended to the outside of the pump casing, the stroke control shaft may be attached for either manual or automatic pressure control. The manufacturers



particularly recommend this pump for hydraulic press applications where a rapid advance must be followed by slow movement at high pressure and for boiler feed where sudden changes in output effect water level. Equipped with a 25-hp. motor, the entire unit is but 4 ft. high and requires floor space of only 4x4 ft. It weighs 5,000 lb. Other units can be built for designed pressures ranging from a few hundred to 10,000 lb. per sq. in. Watson-Stillman Co., Roselle, N. J.

Line of Rectifiers

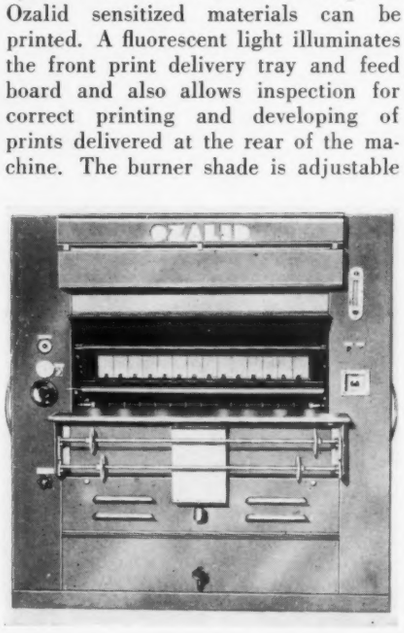
A new line of full-wave rectifiers for all industrial purposes has eleven models ranging in capacities from 100 to 15,000 watts. Two high-capacity, single plate tubes, one for each half cycle, have a 2,000-hr. guarantee. These are housed in cabinets designed for wall mounting, a hinged cover providing accessibility for replacements. As a terminal strip is provided for con-



necting the a-c input and d-c output lines, installation of the rectifier is simple. The control switch is mounted on the door of the cabinet and an indicating light shows when the unit is in operation. Weltronic Corp., E. Outer Drive, Detroit, Mich.

Whiteprint Machine

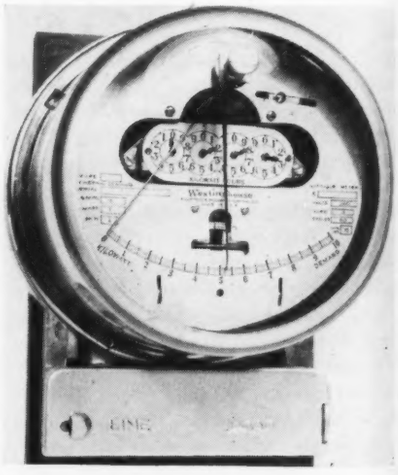
Capable of producing finished whiteprints at speeds up to 20 ft. per min. (max. width 42 in.), this new Model B whiteprint machine has a temperature control for the printing cylinder so that the entire range of Ozalid sensitized materials can be printed. A fluorescent light illuminates the front print delivery tray and feed board and also allows inspection for correct printing and developing of prints delivered at the rear of the machine. The burner shade is adjustable



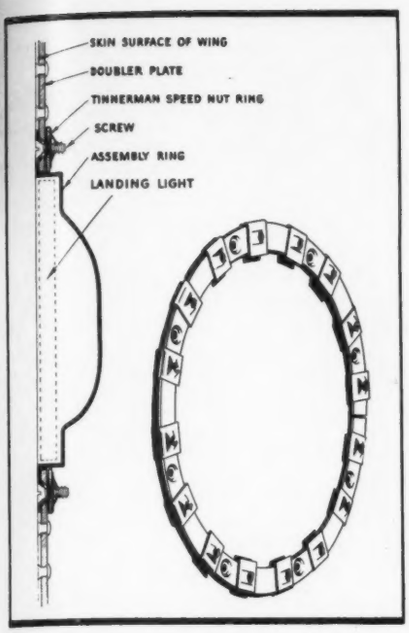
to permit the running of prints of varying opacity without change in printing speed. A blower hook-up creates the vacuum for the automatic separation of original from print, air pressure for the automatic pick-off device, and a slight vacuum inside the machine which prevents small leakage of ammonia fumes from escaping from the developer. Occupying only 19 sq. ft. of floor space, the machine requires only one operator. Ozalid Products Div., Gen. Aniline & Film Corp., Johnson City, N. Y.

Combination Watthour and Thermal Demand Meter

In standard house size, case and mounting, a new, low-cost combination watthour and thermal demand meter has been developed. The unit has a-c ratings of 5, 15 and 50 amps., 120 to 240 volts, 2 and 3 wire for reading up to 20 kw. and is similar in general appearance to the ordinary watthour meter. In eliminating the self-contained transformer used in previous thermal meters, the voltage component of the thermal element is fed by a secondary coil wound over the potential coil of the watthour meter, thus making possible the combination in one unit. Improved design of the thermal



unit is said to reduce greatly the required operating energy. Two demand pointers operate as a pusher and indicator of maximum demand respectively. Accurately balanced, the latter is held in position by an adjustable friction device to eliminate shifting due to vibration. The watthour mechanism has standard adjustments for load and power factor, and the thermal unit has two adjustments—for zero and full load. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

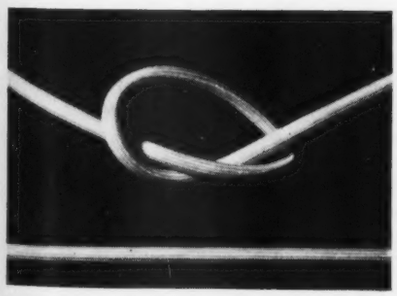


Speed Nut Ring

For attaching aircraft landing lights, hand hold plates and access doors, an assembly device has been designed with floating "U" type Speed Nuts snapped over an aluminum carrying ring. This ring may be riveted to a doubler plate or other structure and the degree of float governed by the size of holes over which the nuts fit. It is claimed that this type of assembly weighs only 30 or 40 percent as much as former fasteners and that it reduces net assembly costs from 70 to 80 percent. Timerman Products, Inc., 2041 Fulton Rd., Cleveland, Ohio.

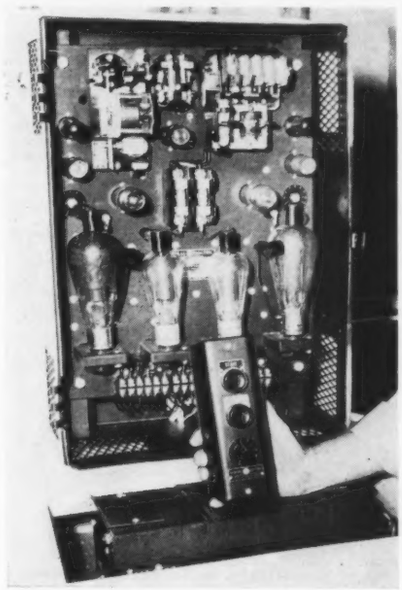
Varnished Glass Sleeving

Higher dielectric strength and increased flexibilty are properties claimed for Turbo Glass Sleeving now processed with a natural oil base varnish. According to the manufacturers, comparative tests show that this varnish application reduces the stretch factor to a practical minimum, providing greater stability in applications requiring bending at acute angles. Listed as a special feature of this material is its precise roundness whereby objectionable circumferential wrinkles and gaps are eliminated. It comes in two grades, in all standard diameters. William Brand & Co., 276 Fourth Ave., New York, N. Y.

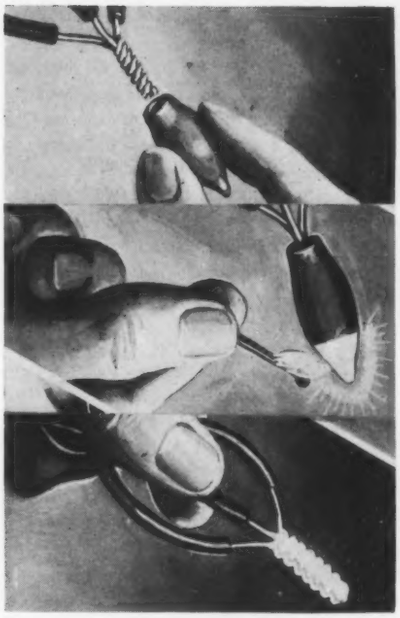


Electronic Motor Control

To provide simple, stepless, wide-range speed control of d-c motors operating from a-c lines, a new electronic control system, called "Thy-mo-trol, has been announced. Consisting of three



separate units—a small control station, transformer, and thyraton tube panel—the control provides in one equipment the means for electronically starting, stopping, accelerating and regulating the speed of a motor. Standard units cover motor sizes up to 5 hp., 230 volts. A single-dial control, mounted in a heavy-duty push-button station, covers the complete speed range of the motor, both above and below basic speed. The motor is automatically accelerated to preset speed quickly and smoothly without excessive current peaks. Changes in speed during operation are accomplished by the same dial. Thy-mo-trol equipment can be provided for reversing service and for dynamic braking. The control holds motor speeds constant regardless of normal-load and line-voltage variations. Stepless speed control increases armature voltage up to basic speed and weakens the field at speeds above basic. Acceleration is automatic. Full field is held until basic speed is reached and is also applied during dynamic braking. A thermal overload relay protects the motor on sustained overloads; fuses provide d-c short-circuit protection. General Electric Co., Schenectady, N. Y.

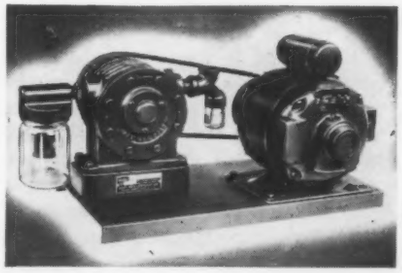


Soldering Device

"Jiggers" is the name of a device said to be "a complete soldering kit in a nutshell" for soldering electric wire splices. A jigger consists of a hermetically sealed, waterproof, heat-generating shell containing correct amounts of flux and solder. To obtain a soldered connection, the wire splice is pushed into the shell which is then touched with a lighted match. After the shell ignites and burns at the proper temperature to flow over the splice solder, the burnt remains are dropped off. A smooth, soldered splice is said to be obtained and no soldering iron, torch or solder pot is needed. Jiggers, Inc., 215 W. Illinois St., Chicago, Ill.

Rotary Air Pump

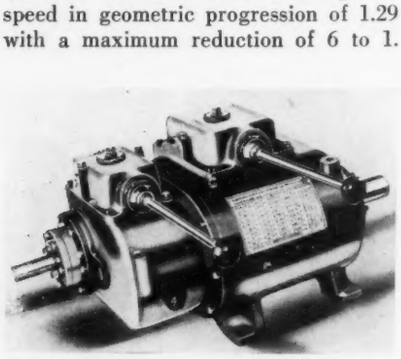
Especially suited for such operations as paper feeding, lithographer's film plate holders, milking machines and other slow-speed applications, this new V-belt driven rotary air pump, Model 15F50, can be adapted for operation with ¼, ⅓, ½, and ¾ hp. motors by changing the size of the motor pulley. Advantages claimed for the pump are slow, quiet operation, long life, ease of installation regardless of shaft



height or diameter, and low power required in proportion to the large air volume delivered. A heavy duty shaft and large ball bearings take care of belt side-thrust. The pump sheave incorporates a cooling fan. This rotary design provides operation without gears, springs or valves, which is said to result in economical and trouble-free performance. Gast Manufacturing Corp., Hinkley St., Benton Harbor, Mich.

Machine Tool Transmission

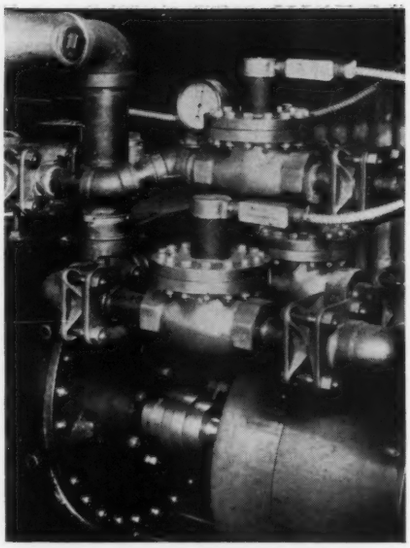
With 30-hp. capacity for motorizing cone driven machine tools, a new transmission the "Super", is suitable for replacement of gear boxes on large boring mills, radial drills, etc. and can be used to motorize large slotters, engine and turret lathes. It has 8 changes of speed in geometric progression of 1.29 with a maximum reduction of 6 to 1.



All gears and shafts are made of alloy steel, heat treated, and shafts run on anti-friction bearings. Case is amply provided with oil seals. This transmission may be adapted to all kinds of machine tools with three models of Multi Motor Mounting as follows: Lathe Bracket, also for motorizing automatics, bolt cutters, Fellows gear shapers, vertical milling machines, screw machines, etc.; Shaper Bracket, also for boring mills, vertical mills, etc.; and Milling Machine Bracket. Western Manufacturing Co., 3428 Scotton Ave.. Detroit. Mich.

High-Pressure Valve

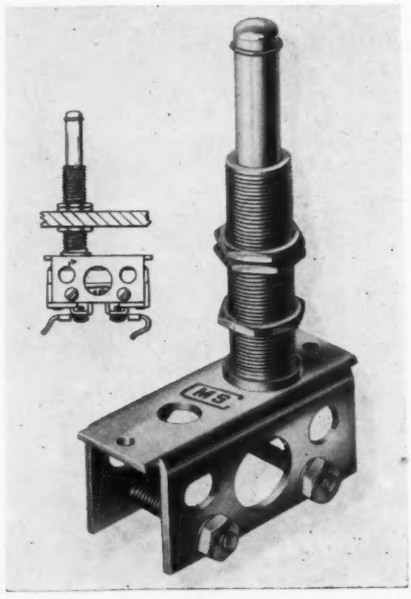
For operating pressures up to 3,000 lb., a new line of "Atkomatic" valves is made in ½, ¾ and 1½-in. sizes and furnished for standard currents. Under some conditions, when used on liquids, an amount of timing control may be obtained on opening and closing speeds. One of these valves is shown operating a 250-ton press at 1,000 lb. oil pressure, with full remote control. Due to an automatic arrangement, when press hits full load, pressure immediately goes to original accumulator pressure with no time lag. Valves are



bronze, packless and rugged. They have screwed ends and renewable seats and disks. Seat diameters can be furnished up to full pipe size. Bubble-tight pilot assembly can be furnished for air and gas operation. E. C. Atkins and Co., 402 S. Illinois St., Indianapolis, Ind.

Panel Mounting Bracket for Micro Switch

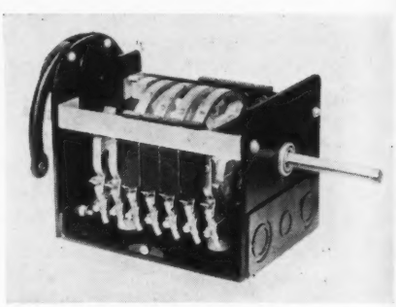
Primarily designed for aircraft, a Type "M" micro switch actuator comes in bracket form for panel mounting. Principal advantages of the unit are (1) variety of application because of the sturdiness of the assembly, (2) protection given the micro switch unit, (3) ease of switch replacement without removing actuator from panel mounting, and (4) location of point of



operation can be changed simply by adjusting the panel mounting. Mounting is by three hex nuts, two to position the switch and the third to lock the assembly in place. The actuator can be mounted in holes $\frac{13}{32}$ in. in diameter on panels up to 1⅜ in. thick. Three lengths of plungers are available—Type M-2 allows for ¼-in. overtravel and has a short bushing; Type M-7 allows ⅞-in overtravel and has a long bushing; and Type M-27 is a hybrid having ¼-in. overtravel and a long bushing. Micro Switch Corp., Freeport, Ill.

Drum Controllers

Features incorporated in a new line of drum controllers for small cranes and hoists include a rope operating lever and a new anti-plug system. The former, embodying an equalized torque principle, eliminates cumbersome sheave wheel, rope guard, and external return spring, providing smooth, easy



operation, according to information received, even when the rope is pulled at an angle. An increase in drum life is made possible by the anti-plug feature which makes it impossible to whip drum from full forward to full reverse position. Drum can be reversed rapidly, but a definite time delay is required in the off position. New drums come in self-centering rope lever, self-centering and non-self-centering radial lever types, for four or six speeds. Cutler-Hammer, Inc., Milwaukee, Wis.

Coolant Pumps

Features of a new series of coolant pumps among which is the Model 17 shown include (a) open impeller which allows small chips or grit to pass through the pump without harming it, (b) no stuffing box, (c) compact design for installation in small space, and (d) no priming. Designed for use on lathes, shapers, and other machines where a steady stream of coolant or cutting oil is necessary, they are also suitable for pumping non-viscous liquids for cooling and circulating appli-

cations. "Long" and "Short" models are 19¾ in. and 16¾ in. high, respectively; the former weighs 35 lb., the latter 30. The ⅛-hp., 1725 r.p.m., impulsion induction motor is semi-inclosed. As there is no metal to metal contact below the liquid level, the handling of non-lubricating liquids is possible. Of centrifugal type, these pumps have a maximum capacity of 17 gal. per min. at maximum pressure of 6 lb. per sq. in. They are furnished in a variety of mountings. Eastern Engineering Co., 45 Fox St., New Haven, Conn.

T-Connector

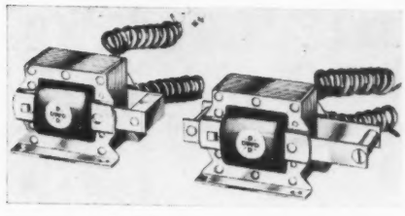
For tapping cable from tubing, the Type NVT connector accomodates a large range of cable sizes through a flattened U-bolt on the tap. Also, the large compressive range of this bolt makes it especially suitable for clamping flexible and extra-flexible cables. Where mechanical stresses are considerable, two U-bolts may be desired. On large conductor sizes, four oval-shank Everdur bolts are used to clamp the run conductor. Two bolts are used for small sizes. Good contact without mutilation of cable strands is insured by the large, flat clamping surface of the U-bolt. Burndy Engineering Co., Inc., 107 Eastern Blvd., New York.

Cutting Machine

Through the use of old razor blades, this trimming machine can be employed to cut to size blue prints, tracings, photographic paper, leather, cloth, etc. Margins from ⅜ in. to 2 in. are said to be obtained automatically around frames. It comes in four sizes, 32-, 38-, 50-, and 62-in. with cutting sizes, respectively, 25, 31, 43, and 55 in. Edi Trimming Machine Co., 611 W. 112th St., New York, N. Y.

Laminated Solenoid

As illustrated, this new laminated type solenoid is furnished with either push or pull type plunger. The field coil is paper section wound, taped and specially treated to be impervious to cutting oil. For constant or intermittent duty on a.c., the manufacturers state, this solenoid meets demands for rugged construction and positive reliability in control of production machinery, operation of hydraulic valves, and so forth. Measuring 2x2 in., these solenoids have a plunger stroke of ¾ in. and may be had for any voltage. They have a minimum push or pull of 5.5 lbs. at full line voltage and 3.75 lbs at 85 percent of full line voltage. Dean W. Davis & Co., Inc., 549 W. Fulton St., Chicago, Ill.



New Switch Design

New principles claimed for an advanced design of Vacu-break Safety Switches include "Clampmatic" switch contacts, whereby perfect clamp pressure of the switch contacts is maintained when in the "on" position; while a normal push of the operating handle will make or break the circuit with ease. The operating mechanism transmits a direct overcenter action to the switch contacts, ensuring positive make or break. The formed bakelite arcing chamber is of more simple design and durable material. Elimination of lost motion is an advantage of the front operating, push type, rocker handle. Knife-edge, two-point bearings provide great sensitivity for positive operation. This switch is available in capacities from 30 to 200 amps, inclusive, in both Master (Type "A") line and Standard (Type "C") line. Bulldog Electric Products Co., 710 Jos. Campau Ave., Detroit, Mich.

Washable Protective Film

This washable protective covering for flat wall paint is designed for use in drafting rooms, plants, warehouses and offices where it is desirable to provide for easy cleaning of painted walls. It may be applied over a cleaned or newly painted wall and provides a clear, transparent, flat protective film that prevents dust, dirt and grime from penetrating the pores of the paint. It dries flat within 20 min. at 70 deg. F., and possesses high ability to reflect and diffuse light. One gallon covers approximately 1,500 sq. ft. This film, named "Bergonize," is removed by application of clear water with a sponge or rag, taking with it all dirt and leaving the surface in its original paint-clean condition. It is not recommended for use where considerable steam escapes into the air, or where condensation takes place on the walls or ceilings. The Bergonize Co., Merchandise Mart, Chicago.

Books and Bulletins

Engineering Tools and Process

HERMAN C. HESSE—*627 pages, 6½x 9¼ in. 903 illustrations. Maroon buckram covers. Published by D. Van Nostrand Co., Inc., 250 Fourth Ave., New York. Price* $4.50.

No design engineer doubts that he must be well acquainted with the possibilities and limitations of manufacturing methods, but many are so remote from the shop that they need an occasional brushing up of their production background. This book meets this need quite adequately.

The first three chapters offer a survey of basic materials, elements and devices. Then the book takes up the study of shop processes and practices, placing particular emphasis on production machinery. Because of his broad coverage of production technique, the author goes beyond the average college text book which presents only basic processes and machines.

The text concludes with a discussion of important design considerations and the manner in which they affect production economy and feasibility. The book contains an excellent bibliography, and is so arranged as to facilitate reference.

Testing and Inspection of Engineering Materials

HARMER E. DAVIS, GEORGE E. TROXELL, and CLEMENT T. WISKOCIL—*372 pages, 7x10 in. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York, N. Y. Price* $3.50.

Assembled in this volume in condensed form are much pertinent data and specifications dealing with the properties of engineering materials and the methods used in testing laboratories for determining those properties.

Divided into two sections, the text deals first with the concepts and general principles of testing and inspection and second with the methods of conducting common tests in the laboratory.

The book, although written for class room work, is of interest and value to engineers and designers who are charged with the responsibility of developing adequate, enforceable specifications for the control of quality in materials through appropriate inspection processes.

Included as an appendix is a list of approximately 240 references to selected sources of authoritative information.

Standard Handbook For Electrical Engineers

A. E. KNOWLTON, *Editor-in-Chief—Seventh Edition, 2303 pages, 6x9 in. Red leatheroid flexible covers. Published by the McGraw-Hill Book Co., Inc., 330 West 42nd St., New York, N. Y. Price* $8.

This new edition of this popular handbook is designed to be primarily an encyclopedia of usable information and also a compendium of theories and principles relating to the various branches of electrical engineering. In the new regrouping of subject matter recognition has been given both to the changing importance of the older branches of the electrical art and to the new provinces of activity that have appeared since the publication of the previous edition.

Prominent among the changes made in this seventh edition is the expansion of the former section on power-plant electrical equipment so that it now embraces electrical equipment for the whole power system. Power transmission, electronics and radio, interior wiring, illumination, prime movers, and telephony are other basically new treatments. Recognition is also given to such typically modern developments as air conditioning, electricity in aviation and in the petroleum industry, lighting technology, high-voltage generators and cyclotrons. The compilation of codes and standards has been greatly expanded so that users of the handbook may know where to obtain standard specifications and prescribed practices.

Industrial Instruments for Measurement and Control

THOMAS J. RHODES—*573 pages, 6x9 in. 282 illustrations. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York, N. Y. Price* $6.

This volume in the Chemical Engineering Series is intended to be both a textbook for the study of instruments and automatic control and also a practical reference book for engineers interested in the comparatively new science of instrumentation which deals with the design, installation and maintenance of instruments.

The author has not attempted to include descriptive material on all the available types and kinds of instruments and controls but rather has limited himself to a discussion of types that illustrate the theories set forth.

Making use of both theoretical and practical treatment, the volume is designed around the four fundamental factors: temperature, pressure, fluid flow and liquid level. The author has thoroughly analyzed the field of control and has set forth many practical rules for the design and maintenance of instruments used for various automatically controlled, continuous processes.

Belt Conveyors and Belt Elevators

F. V. HETZEL and R. K. ALBRIGHT—*Third edition, 439 pages, 6x9 in. Blue clothboard covers. Published by John Wiley & Sons, Inc., New York. Price* $6.

This third edition follows the second edition by 15 years and brings the subject up to date. The authors aim, as in the first edition of 1922, to present practical material by explaining principles and the reasons for doing things rather than restating what appears in trade advertisements and describing installations of this class of machinery. They tell "what is new in present-day practice, what is better and why, and what has become obsolete and why".

The book covers the design of belt conveyors and elevators, starting from early designs and giving reasons for advances in design up to 1940. It includes discussions of belts, largely rubber and fabric belting, belt drives, supports and guides, tension and take-up devices, methods of loading and discharging, maintenance, and when to use belt conveyors.

About one-third of the book is devoted to elevators. Special attention is given to buckets and fastenings in this section in addition to driving problems and loading methods.

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Dielectric Strength of Glass

E. B. SHAND—*A.I.E.E. Preprint from Vol. 60, 1941, 5 pages, 8½x11 in.*

This paper presents data to assist in applying glass more effectively for high dielectric strength. Particular attention is paid to "edge effects" and other factors which cause wide variation in breakdown voltages.

HELICAL TENSION SPRING TABLES — III

PAUL KLAMP

Tension Springs—Table B (continued)

Spring O.D. in.	Wire Dia. in	Load Constant C	Low Stress Group			Medium Stress Group			High Stress Group		
			Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.	Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.	Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.
	0.1055	5.36	12.2	0.441	0.239	14.9	0.359	0.294	17.9	0.299	0.353
	0.1205	10.7	18.0	0.595	0.203	22.1	0.485	0.249	26.6	0.404	0.299
	1/8	13.0	20.1	0.646	0.193	24.7	0.527	0.237	29.6	0.439	0.285
	0.135	19.5	25.2	0.772	0.175	31.0	0.629	0.215	37.2	0.525	0.257
	0.1483	32.0	33.3	0.962	0.154	40.9	0.783	0.189	49.0	0.653	0.227
	5/32	42.3	38.9	1.09	0.144	47.7	0.885	0.177	57.3	0.738	0.212
	0.162	51.2	43.2	1.18	0.137	53.1	0.965	0.168	63.7	0.804	0.201
	0.177	82.2	56.1	1.47	0.121	68.8	1.20	0.148	82.6	0.996	0.178
1 5/8	3/16	112	66.4	1.69	0.111	81.5	1.38	0.136	97.8	1.15	0.164
	0.192	127	71.2	1.79	0.107	87.4	1.46	0.132	105	1.21	0.158
	0.207	192	88.7	2.16	0.0958	109	1.76	0.118	131	1.47	0.141
	0.2253	304	114	2.68	0.0841	139	2.18	0.103	167	1.82	0.124
	0.2437	469	130	3.62	0.0674	156	3.01	0.0809	187	2.51	0.0970
	1/4	540	140	3.87	0.0646	167	3.23	0.0775	201	2.69	0.0930
	0.2625	708	161	4.41	0.0595	193	3.67	0.0714	231	3.06	0.0858
	0.283	1079	199	5.41	0.0523	239	4.51	0.0627	287	3.76	0.0753
	0.3065	1695	250	6.77	0.0453	300	5.64	0.0543	361	4.71	0.0651
	0.1055	4.22	11.3	0.373	0.283	13.9	0.304	0.347	16.7	0.253	0.417
	0.1205	8.44	16.8	0.503	0.240	20.6	0.410	0.294	24.7	0.341	0.353
	1/8	10.2	18.7	0.547	0.229	23.0	0.445	0.281	27.6	0.371	0.337
	0.135	15.3	23.5	0.651	0.208	28.9	0.530	0.255	34.6	0.442	0.306
	0.1483	25.1	31.0	0.809	0.183	38.1	0.659	0.225	45.7	0.549	0.270
	5/32	33.1	36.2	0.913	0.171	44.4	0.744	0.210	53.3	0.620	0.252
	0.162	40.1	40.3	0.994	0.163	49.5	0.810	0.200	59.3	0.675	0.240
	0.177	64.2	52.3	1.23	0.144	64.2	0.999	0.177	77.1	0.833	0.213
1 3/4	3/16	87.3	62.0	1.41	0.133	76.1	1.15	0.163	91.3	0.957	0.196
	0.192	99.2	66.5	1.49	0.129	81.6	1.22	0.158	97.9	1.01	0.190
	0.207	149	82.8	1.80	0.115	102	1.46	0.142	122	1.22	0.170
	0.2253	235	106	2.22	0.102	130	1.81	0.125	156	1.51	0.150
	0.2437	362	121	2.98	0.0817	145	2.49	0.0981	175	2.07	0.118
	1/4	416	131	3.19	0.0785	157	2.66	0.0942	188	2.21	0.113
	0.2625	544	150	3.62	0.0725	180	3.02	0.0870	217	2.51	0.104
	0.283	827	187	4.42	0.0640	224	3.68	0.0768	269	3.07	0.0922
	0.3065	1293	234	5.51	0.0556	281	4.59	0.0667	338	3.83	0.0801
	5/16	1442	248	5.80	0.0538	298	4.84	0.0646	358	4.03	0.0775
	0.1205	6.76	15.7	0.431	0.280	19.3	0.351	0.343	23.1	0.293	0.412
	1/8	8.19	17.5	0.468	0.267	21.5	0.381	0.328	25.8	0.318	0.394
	0.135	12.2	22.0	0.556	0.243	27.0	0.453	0.298	32.4	0.378	0.357
	0.1483	20.0	29.1	0.689	0.215	35.7	0.562	0.264	42.8	0.468	0.317
	5/32	26.4	33.9	0.777	0.201	41.6	0.634	0.247	49.9	0.528	0.296
	0.162	31.9	37.7	0.846	0.192	46.3	0.689	0.235	55.6	0.574	0.282
	0.177	51.0	49.0	1.04	0.170	60.1	0.848	0.209	72.2	0.707	0.251
	3/16	69.3	58.1	1.19	0.157	71.3	0.973	0.193	85.5	0.810	0.231
	0.192	78.7	62.3	1.26	0.152	76.4	1.03	0.187	91.8	0.858	0.224
1 7/8	0.207	118	77.7	1.52	0.137	95.4	1.23	0.168	114	1.03	0.201
	0.2253	186	99.6	1.87	0.121	122	1.52	0.148	147	1.27	0.178
	0.2437	285	114	2.50	0.0977	137	2.08	0.117	164	1.73	0.141
	1/4	327	123	2.67	0.0938	147	2.22	0.113	177	1.85	0.135
	0.2625	427	141	3.02	0.0869	170	2.52	0.104	204	2.10	0.125
	0.283	647	176	3.68	0.0770	211	3.06	0.0924	253	2.55	0.111
	0.3065	1008	221	4.55	0.0673	266	3.79	0.0808	319	3.16	0.0970
	5/16	1123	234	4.80	0.0651	281	4.00	0.0782	337	3.33	0.0938
	0.331	1552	276	5.62	0.0589	331	4.68	0.0707	398	3.90	0.0848

(Continued on next page)

Tension Springs—Table B (continued)

Spring O.D. in.	Wire Dia. in	Load Constant C	Low Stress Group			Medium Stress Group			High Stress Group		
			Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.	Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.	Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.
	1/8	6.66	16.4	0.405	0.309	20.2	0.330	0.379	24.2	0.275	0.455
	0.135	9.94	20.7	0.481	0.281	25.3	0.392	0.344	30.4	0.327	0.413
	0.1483	16.2	27.3	0.595	0.249	33.5	0.484	0.306	40.2	0.404	0.367
	5/32	21.4	31.9	0.670	0.233	39.1	0.546	0.286	47.0	0.455	0.344
	0.162	25.8	35.5	0.728	0.222	43.5	0.593	0.273	52.2	0.495	0.328
	0.177	41.2	46.1	0.895	0.198	56.5	0.729	0.243	67.8	0.608	0.291
	3/16	56.0	54.6	1.03	0.183	67.0	0.835	0.225	80.4	0.696	0.269
	0.192	63.5	58.6	1.08	0.177	71.9	0.882	0.218	86.3	0.735	0.261
2	0.207	94.8	73.1	1.30	0.160	89.8	1.06	0.196	108	0.880	0.235
	0.2253	149	93.8	1.59	0.142	115	1.30	0.174	138	1.08	0.209
	0.2437	228	107	2.13	0.115	129	1.77	0.138	155	1.48	0.165
	1/4	262	116	2.27	0.110	139	1.89	0.132	167	1.57	0.159
	0.2625	342	133	2.56	0.103	160	2.13	0.123	192	1.78	0.148
	0.283	515	166	3.11	0.0911	199	2.59	0.109	239	2.16	0.131
	0.3065	801	209	3.83	0.0801	251	3.19	0.0961	301	2.66	0.115
	5/16	892	221	4.03	0.0775	266	3.36	0.0930	319	2.80	0.112
	0.331	1228	261	4.71	0.0703	313	3.92	0.0844	376	3.27	0.101
	0.3625	2049	339	6.05	0.0599	406	5.04	0.0719	488	4.20	0.0863
	0.1483	11.1	24.4	0.456	0.325	29.9	0.371	0.399	35.9	0.310	0.479
	5/32	14.6	28.5	0.513	0.305	34.9	0.418	0.374	41.9	0.348	0.449
	0.162	17.6	31.7	0.556	0.291	38.9	0.453	0.357	46.6	0.378	0.429
	0.177	28.0	41.2	0.681	0.260	50.5	0.555	0.319	60.6	0.462	0.383
	3/16	38.0	48.8	0.777	0.241	59.9	0.633	0.296	71.9	0.528	0.355
	0.192	43.0	52.4	0.822	0.234	64.3	0.670	0.287	77.1	0.558	0.344
	0.207	64.1	65.4	0.979	0.211	80.2	0.798	0.259	96.3	0.665	0.311
	0.2253	101	84.0	1.20	0.188	103	0.975	0.231	124	0.813	0.277
2 1/4	0.2437	153	96.2	1.59	0.153	115	1.33	0.184	138	1.11	0.221
	1/4	175	104	1.69	0.148	124	1.41	0.177	149	1.18	0.213
	0.2625	228	120	1.91	0.138	144	1.59	0.165	172	1.33	0.198
	0.283	343	149	2.30	0.123	179	1.92	0.148	215	1.60	0.177
	0.3065	530	188	2.82	0.109	226	2.35	0.131	271	1.96	0.157
	5/16	589	199	2.96	0.106	239	2.47	0.127	287	2.06	0.152
	0.331	808	235	3.44	0.0963	282	2.86	0.116	339	2.39	0.139
	0.3625	1338	306	4.38	0.0828	367	3.65	0.0994	440	3.04	0.119
	3/8	1617	337	4.80	0.0782	405	4.00	0.0938	485	3.33	0.113
	5/32	10.4	25.7	0.405	0.386	31.5	0.330	0.474	37.8	0.275	0.568
	0.162	12.6	28.6	0.439	0.369	35.1	0.358	0.453	42.1	0.298	0.544
	0.177	19.9	37.2	0.536	0.330	45.6	0.436	0.406	54.8	0.364	0.487
	3/16	26.9	44.1	0.610	0.307	54.2	0.497	0.377	65.0	0.414	0.452
	0.192	30.5	47.4	0.644	0.298	58.1	0.525	0.366	69.7	0.438	0.439
	0.207	45.3	59.2	0.766	0.270	72.6	0.624	0.332	87.1	0.520	0.398
	0.2253	70.9	75.9	0.934	0.241	93.2	0.761	0.296	112	0.634	0.355
	0.2437	108	89.5	1.20	0.203	107	1.00	0.243	129	0.834	0.292
2 1/2	1/4	123	93.8	1.31	0.190	113	1.09	0.228	135	0.912	0.274
	0.2625	160	109	1.47	0.179	131	1.22	0.214	157	1.02	0.257
	0.283	240	135	1.77	0.160	162	1.48	0.192	194	1.23	0.230
	0.3065	368	171	2.16	0.142	205	1.80	0.170	246	1.50	0.204
	5/16	409	181	2.27	0.138	217	1.89	0.166	260	1.57	0.199
	0.331	560	214	2.62	0.126	256	2.18	0.152	308	1.82	0.182
	0.3625	921	278	3.31	0.110	334	2.76	0.132	401	2.30	0.158
	3/8	1111	307	3.62	0.104	368	3.02	0.124	442	2.51	0.149
	0.3938	1457	354	4.12	0.0956	424	3.44	0.115	509	2.86	0.138
	0.177	14.7	33.9	0.432	0.410	41.7	0.352	0.503	50.0	0.293	0.604
	3/16	19.8	40.3	0.492	0.381	49.4	0.401	0.468	59.3	0.334	0.562
	0.192	22.4	43.2	0.519	0.370	53.0	0.423	0.454	63.6	0.352	0.545
	0.207	33.2	54.0	0.615	0.336	66.3	0.501	0.413	79.5	0.418	0.496
	0.2253	51.9	69.4	0.748	0.301	85.1	0.609	0.370	102	0.507	0.444
	0.2437	78.5	79.5	0.987	0.247	95.4	0.823	0.296	114	0.686	0.355
	1/4	89.9	85.8	1.05	0.239	103	0.873	0.286	123	0.728	0.344
	0.2625	116	99.0	1.18	0.223	119	0.979	0.268	143	0.816	0.322
2 3/4	0.283	174	124	1.41	0.201	148	1.17	0.241	178	0.977	0.290
	0.3065	267	156	1.71	0.180	187	1.42	0.216	225	1.19	0.259
	5/16	296	165	1.79	0.175	198	1.49	0.210	238	1.24	0.252
	0.331	404	196	2.06	0.161	235	1.72	0.193	282	1.43	0.231
	0.3625	661	255	2.59	0.140	306	2.16	0.168	368	1.80	0.202
	3/8	796	282	2.82	0.133	338	2.35	0.159	406	1.96	0.191
	0.3938	1041	325	3.20	0.123	390	2.67	0.147	468	2.23	0.177
	7/16	1863	441	4.23	0.103	529	3.52	0.124	634	2.94	0.149